**ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY**

# MASS CUSTOMIZATION OF ARCHITECTURE
# ARCHITECTURE IN THE INFORMATION AGE

**M.Sc. THESIS**

**Efe GÖZEN**

**Department of Architecture**

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**İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ**

# MİMARLIĞIN KİTLESEL ÖZELLEŞTİRİLMESİ BİLGİ ÇAĞINDA MİMARLIK

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**EKİM 2011**

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| | | |
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**Date of Submission : 16 September 2011**
**Date of Defense : 27 October 2011**

***To my family,***

## FOREWORD

This thesis is dedicated to my parents who have always supported me to explore, to Yasemin Cennet Sünbül for her mutual mindset, to Bilge Can for always being there for me, and to Лайка.

This thesis would not exist if it were not for the masochistic bond between TU Delft Hyperbody and me. Big up for all the people whom I had a chance to meet in Delft.

I also have to thank Uğur Tanyeli for sparing his invaluable time for his interview, as well as Arzu Erdem and Bülent Tanju for their precious input on the subject.

A special thanks and dedication for my thesis / graduation advisors Arda İnceoğlu, Henriette Bier and Nimish Biloria, who have always pushed me to be more than what I am.

November 2011

Efe GÖZEN
Architect

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## ABBREVIATIONS

**BIM** : Building Information Modeling
**CAD** : Computer Aided Design
**CAM** : Computer Aided Manufacturing
**CIAM** : Congrès International d'Architecture Moderne
**CNC** : Computer Numerical Control
**DIY** : Do-it-Yourself
**EMP** : Experience Music Project
**F2F** : File to Factory
**MC** : Mass-Customization
**MEL** : Maya Embedded Language
**ONL** : Oosterhuis and Lénard
**SLA** : Stereolithography
**ZHA** : Zaha Hadid Architects

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**MASS CUSTOMIZATION OF ARCHITECTURE**


**SUMMARY**

This thesis discusses the possible applications of mass customization in the field of architecture. A novel fabrication method from the hybridization of mass standardization and full customization, mass customization aims to provide unique customer experience for all. Mass customization has established itself as the rule of thumb in many industrial fields, yet it is still an emerging method in the field of architecture. Also discussed in this thesis is the role of the architect in this new paradigm.

For a better understanding of the current phenomenon and its possible effects on the profession, precedent production methods and their effects are discussed briefly in the second chapter, *Waves*. Introduction of new production methods causes paradigm shifts, affecting all aspects of life. Named as Waves by Alvin Toffler, paradigm shifts taking place between waves make a great impact on the profession of architecture, and the user/client. Evolutions of both sides through the previous waves are emphasized in this chapter.

As the reader gains a general background to production methods and their effects, mass customization as a phenomenon is introduced in the self-titled third chapter, *Mass Customization*. Emergence of the method is introduced and a thorough classification of the concept is provided, serving as a clear basis for identification of different cases of mass customization. Two essential aspects of mass customized systems, modularity and customer involvement, is further discussed. The difference between variety, which is often mistaken as a mass customization quality, and mass customized products are discussed in the last sub-chapter.

Chapter 4, *Mass Customization of Architecture*, builds on the previous chapter and introduces the possible applications of mass customization in the field of architecture, classified based on the phase of the production cycle. Mass customization in *Design Phase* focuses on the new digital design methods and computational tooling, while classifying various methods according to their level of effective use of computational power. *Fabrication Phase* explores different digital fabrication methods that were primarily developed for other fields, but has found their way into the fabrication of building elements. Possible applications of mass-customization in the use phase are discussed under *Interactive Architecture*. Further *Case Studies* are briefly explained and evaluated at the end of the chapter.

*Conclusions* summarizes the study including an evaluation of the subject by the author.

# MİMARLIĞIN KİTLESEL ÖZELLEŞTİRİLMESİ

## ÖZET


Bu tez, bilgi çağındaki mimar / mimarlığı incelemektedir ve kitlesel özelleştirmenin mimarlığa olası yansımalarını ele almaktadır. Standartlaşma ve özelleştirmenin melezlenmesi sonucu ortaya çıkan bu özel üretim yönteminin amacı her kullanıcıya eşsiz bir kullanım değeri kazandırmaktır. Kulağa her ne kadar paradoksal gelse de, kitlesel özelleştirme yöntemleri bir çok endüstri için vazgeçilmez bir standard haline gelmiştir. Her ne kadar bir çok endüstri alanında temel yöntem haline gelmişse de, kitlesel özelleştirmenin mimarlığa uyarlanması nispeten yenidir. Tez, mimarın bu yeni paradigmadaki rolünü de konu almaktadır.

Bu güncel fenomeni ve meslek üzerindeki etkilerini daha iyi anlamak için önce mesleğin tarih içindeki gelişimini, sonra da bu fenomenin ortaya çıkışını incelemek gerekir. Böylece mesleğin tarih içinde gösterdiği değişimlerden yola çıkarak günümüz mimar ve mimarisi hakkında bir fikir elde edebiliriz.

Mesleğin evrimini kavrayabilmek için değişimleri tarihsel bir altlığa oturtmak gerekir. Bu noktada Alvin Toffler'ın *Wave* (Dalga) adını verdiği paradigma kaymaları dönüm noktaları olarak alınabilir. 1980'de yayınlanan *3$^{rd}$ Wave* adlı kitabında Alvin Toffler üretim yöntemlerinin toplum hayatında derin izler bıraktığını savunmakta ve değişik üretim yöntemlerinin toplumun üstündeki etkilerini incelemektedir. Mimarlığın evrimi üretim yöntemlerinin evrimi ile çakıştırılarak okunmuştur. Böylece değişik dönem mimarlıklarının mimarının diğer mesleklerle olan ilişkisi, mimarın eğitimi ve mimarın ihtisaslaşması gibi konuları karşılaştırmak mümkündür.

Toffler'a göre yerleşik hayata geçilmesini ve ilk toplumların oluşmasını sağlayan tarım odaklı üretim sistemi *İlk Dalga*yı oluşturur. Toplumsal dayanışma kurgusu sonucu meslekler, ve mimarlık, bu çağda ortaya çıkar. *İkinci Dalga* ise sanayi devrimiyle birlikte etkisini gösterir. Mesleklerin ortaya çıkmasına önayak olan verimlilik arzusu, sanayi devrimi ile birlikte zirve yapar. Seri üretim, standartlaşma, kitlesel tüketim ve kitlesel eğitim sanayi devrimi ile çıkmış, pazar önem kazanmıştır. İkinci Dünya Savaşı'ndan sonra ise İkinci Dalga'da çıkan eğilimlerde başkalaşımlar görülmüştür. Toffler bu dönemin *Üçüncü Dalga*'nın başlangıcı olduğunu iddia eder. Üçüncü Dalga bilginin üretiminin öne çıktığı bir dönem olduğundan, bu dönemi Bilgi Çağı olarak da adlandırabiliriz.

Üçüncü Dalga'nın standartlaşmadan, ve seri üretimden uzaklaşan yaklaşımı mimarlığı ve mimarı geç de olsa etkilemeye başlamıştır. Mimarlık eğitimi daha esnek bir yapıya kavuşurken, mimarın fazla ihtisaslaşmasının getireceği zararı önlemek amacıyla, diğer meslek gruplarıyla olan ilişkisini de kapsayan bütünsel bir yaklaşım benimsenmeye başlamıştır.

Sanayi toplumundan bilgi toplumuna geçiş tüketiciyi de etkilemiştir. Mimarlık, günümüzdeki doğası gereği, birden çok tüketici kesminin bulunduğu bir ortamdır. Mekanı kullananın kullanıcı olduğunu kabul edersek, sanayi devriminin sebep olduğu paradigma kaymasının kullanıcıyı derinden etkilediğini söyleyebiliriz. Baudrillard'ın *Tüketici Toplumu*'nda belirttiği üzere, sanayii devrimi ile nesnelerin materyalistik özellikleri ikinci plana kayarken, nesneyi ayırt edici kılan nitelediği semboller ön plana çıkmıştır. Bu semboller tüketicinin *tin*ini tanımlamasının bir parçasıdır. Bir diğer deyişle tüketici sahip olduğu objeler aracılığıyla kendisini dünyaya tanıtır. Ancak devamlı büyümekte olan bir dünyada seri üretim ve seri tüketim alışkanlıkları bu süreçte sürdürülebilir değildir, bu yüzden sanayi öncesi topluluklarında hakim olan, kısmi de olsa, kendine yeterlilik durumu incelenmeli ve pazara olası entegrasyonu sorgulanmalıdır.

Tüketici/Üretici diyalektiğinden doğan kitlesel özelleştirme her ne kadar paradoksal bir durum olarak gözükse de, bu entegrasyonun sürdürülebilir bir sonucudur ve bir çok endüstri dalında değişilmez bir konuma sahiptir. Kitlesel özelleştirme, her ne kadar üstüne sayısız makale yazılmış olsa da, hala tam olarak tanımlanamamıştır. Her durumu kapsayan belirli bir tanım yerine, seri üretim ve özel üretim arasında konumlandırılmış çeşitli basamaklardan oluşan bir ölçü ile kitlesel özelliştirmeyi tanımlamak daha doğru olacaktır.

Kitlesel özelleştirme yaklaşımları ne kadar farklı olursa olsun, iki özellik her yaklaşımda bulunmalıdır: modülarite ve tüketicinin üretime katkısı. Bir yaklaşımın kitlesel özelleştirme ölçüsündeki konumu bu iki özelliğin yaklaşımlarda bulunma oranına bağlıdır. Tüketici kararlarının üretim döngüsüne dahil olma aşamasına (tasarım / üretim/ tüketim) bağlı olarak farklı modüler yaklaşımlar kullanılabilir.

Kitlesel özelleştirme çeşitlilik değildir. Çeşitlilik, tepeden inme bir tasarım kararıdır. Oluşturulan pazar kesimlerine hitap etme amacıyla seri üretimin farklılaşmasıdır, kitlesel *özelleştirme* değildir. Aynı şekilde her tüketici için farklı üretim de *kitlesel* özelleştirme değildir. Çeşitlilik karar alma ve müşteri memnuniyetinde sorunlar yaratabilirken, kitlesel özelleştirmede müşteri odaklı bir çözüm vardır. Çeşitlilik ekolojik ve ekonomik açıdan sürdürülebilir değildir, sürdürülebilirlik ancak kitlesel özelleştirme ile sağlanabilir. Getirdiği avantajlar nedeni ile kitlesel özelleştirme bir çok endüstri dalında benimsenmiştir.

Yapı endüstrisi, ölçeği, her projenin özelleşmesi ve ilgilendiği kişisel mekan üretimi faktörleri dolayısıyla diğer endüstrilerden farklılaşır. Yeni üretim biçimleri yapı üretiminde daha geç kabul görmüştür. Nispeten yeni bir üretim sistemi de olsa, kitlesel özelleştirmenin etkileri görülmeye başlanmıştır. Yapı endüstrisi bir çok farklı kesimi bir araya getirdiği için üretim döngüsünün basamakları dahilinde kitlesel özelleştirmenin incelenmesi gerekir.

Tasarım aşaması mimarlara atfedilmiştir, ve sanayi devriminin getirdiği ihtisaslaşma bağlamında mimarın yetki alanı tasarım süreci ile sınırlandırılmıştır. Oysa kullanıcının isteklerine hitap eden, kullanıcıya farklı deneyimler sunacak olan tasarımlar yeni geliştirilen dijital tasarım ve üretim araçlarıyla mümkündür. Bu araçlara hakim olabilmek için mimar kendini tasarım safhası ile sınırlamamalı, üretim ve kullanım aşamasını da kapsayacak şekilde tasarımını genişletmelidir.

Mimarlar, tasarımın etki alanını genişletebilmek için bilgisayarın sunduğu olasılıklardan yararlanmalıdır. İkinci Dünya Savaşı sırasında ortaya çıkan bilgisayar destekli tasarım (CAD) ve bilgisayar destekli üretim (CAM) araçları geç de olsa mimarlığı etkilemiştir. Ancak bugünkü kullanımı göz önünde bulundurulduğunda mimarların çoğu tasarımlarında bilgisayarın öncelikli görevi olan hesaplamayı es geçmekte, bilgisayarı basit bir dijital çizim aracı olarak görmektedir.

Oysa sayıları az da olsa, bilgisayardan önce de mimarlar bilgisel tasarım araçları kullanmaktaydı. Gaudi'nin kemer tasarımları için geliştirdiği zincir maketi veya Frei Otto'nun Munich Olimpiyat Stadı ve yerleşkesinin üstünü kaplayan asma germe çatı sistemi için geliştirdiği sabun köpüğü düzeneği dijital çağ öncesi bilgisel tasarım araçlarına örnek gösterilebilir.

Bilgisayar destekli tasarım ve üretim araçlarının etkili kullanımı için mimar tasarımı nesne üretimi olarak görmemeli, tasarım parçalarının ilişkilerini ön planda tutmalıdır. Tasarım aşamaları göz önünde bulundurularak dijital tasarım araçlarından yararlanma düzeyini belirleyebiliriz. Tasarımı dört aşamada değerlendirecek olursak – dijital ortamda simgelenmesi / oluşumu / değerlendirmesi / performansı, kullanıcının bu aşamalarla dijital veya fiziksel ortamdaki açık veya örtülü ilişkileri dijital tasarım araçlarının kullanılma düzeyini belirler.

Her ne kadar dijital üretim araçları yapı endüstrisine yönelik tasarlanmamış olsalar da, yapı üretimi safhasında dijital tasarım araçları ile birlikte mimarın tasarımı doğrultusunda kullanılabilir. Bilgisayar destekli tasarım ve üretim araçları yapının kullanım aşamasında da yenilikler getirir. Her ne kadar çoğunlukla enstalasyon amaçlı ve kamusal olarak kurgulansa da, etkileşimli sistemler kullanıcılar için yeni bir mimarlığın habercisidir.

Mimarlıkta kitlesel özelleştirmenin kuramsal anlatımının okuyucu tarafından daha iyi anlaşılabilmesi için örnekler üzerinden okumalar yapılmıştır. Özellikle iyi bilinen üç mimar ve tasarımları, Zaha Hadid / Frank O. Gehry / Kas Oosterhuis, üzerinden farklılaşan dijital tasarım ve üretim sistemleri örneklendirilmiş, kitlesel özelleştirme sistemleri ile kurduğu bağ açıklanmıştır. Dijital tasarım araçları ve üretim sistemlerine uzak bir insan tarafından aynı mimarlığı yaptıkları düşünülebilecek *(dekonstruktivist, blob, vb.)* bu üç tasarımcı hem tasarım anlayışları hem tasarım araçları kullanımı bakımından birbirinden oldukça farklılaşmaktadır.

Son olarak, kitlesel özelleştirmenin oluşturabileceği / gelebileceği nihai nokta olarak siberuzay ve mimarlık ilişkisi sorgulanmış, ve Marcos Novak'ın bu konudaki çalışmaları irdelenmiştir.

Sonuç bölümü çalışmayı özetler ve yazarın konu üzerindeki ek görüşlerini bildirir.

*Nosce te Ipsum*[1]

[1] *Latin* "Know Thyself"

## 1. INTRODUCTION

What is architecture? Who is an architect?

This should not be a demanding question, especially for people with design background. If we were to look up a common dictionary, we would stumble upon with the following[2]:

Architecture
**Pronunciation:** /ˈɑːkɪtɛktʃə/
*Noun*
[mass noun]
the art or practice of designing and constructing buildings

Architect
**Pronunciation:** /ˈɑːkɪtɛkt/
*Noun*
a person who designs buildings and in many cases also supervises their construction
a person who is responsible for inventing or realizing a particular idea or project

A simple search on the internet or a quick glance at a book on the history of architecture would yield us facts on how architecture roots as a Greek word of antiquity originally meaning a chief artificer, master-builder, director of works, and is derived from ἀρχιτέκτων (*arkhitekton*), from ἀρχι "chief" and τέκτων "builder, carpenter". The source would go on to tell us how the term later evolves into its Latin form, *architectus*, and with a slight modification matures into its modern English spelling, first appearing on the title page of a book by John Shute in 1563 (Briggs, 1927). Thus, architect would be the person designated to work in the field of architecture.

[2] Definitions are taken from the Oxford English dictionary.

For quite a majority, these explanations would more than suffice, yet they would overlook an interesting point. Considering “Architect” also refers to the person responsible for inventing or realizing a particular idea or a project; how has a “chief carpenter” who is merely an artisan, has transcended its specific professional description and became to be identified as a synonym for the creative director? What happened in the dialogue between the people and the *arkhitekton*? How did this relation evolve into a point where people started characterizing them as creators/inventors, setting them as the exemplary figures for the act of production?

Language tells the nature of a thing. It is an organic tool documenting the values attributed to things by people, helping us comprehend the essence of things. It remains as the first and the highest choice among all forms of communications people can facilitate, creating a common ground for higher degrees of interaction. It is an evolutionary process, taking place in the collective conscious of the masses. A powerful tool, yet often underestimated. Man may act as though *he* were the shaper and master of language, while in fact *Language* remains the master of man (Heidegger, 1971). It is such a common tool facilitated by masses that a man cannot alter the language. Also due to the cumulative nature of the language, things may transform through time spans that exceed the life span of man, forcing these transformations to be deductible only by following generations. Paraphrasing the previous question, how did architect gain its recent values through time, which are well established in the collective conscious of people?

In general, this evolutionary process is slow and steady. Yet, there can be abrupt effects acting as catalyzers in the transformation.[3] In The Structure of Scientific Revolutions, Thomas Kuhn introduces the term paradigm, a new way of looking at the scientific research, a term that is later embraced by many fields. He argues that alongside the cumulative normal science, which he attributes as “puzzle-solving”, a steady and comparably slow process; there is also revolutionary science, where the big leaps are possible by rejecting the cumulative structure of the research.

[3] Taking Darwin’s Theory of Evolution as a model, these abrupt effects can be envisioned as *mutations*.

Kuhn calls the introduction of a new set of values for the existing, or the replacement of the essence of the existing meanings attributed to objects as paradigms (Kuhn, 1962). As researchers introduce new paradigms for existing problems, paradigm shifts occur, documenting a break/leap in the cumulative process of the research. Paradigm shifts should not be conceived as an antonym for the cumulative process, but rather conceived as a breaking point providing novel branching. The concept of paradigm and paradigm shift has been so embraced by all fields of science that it has become a part of everyday life.

Building upon our original question, is it possible that architecture and the architect may have gone through paradigm shifts that have caused this transcendental professional status?

Enter Alvin Toffler, an American futurist writer who was first recognized by *Future Shock* published in 1970 (which later turned out to be a part of a trilogy consisting of *The Third Wav*e published in 1980 and *Powershift* published in 1990). This trilogy focused on technology, and its impacts on society. Introduced most evident in The Third Wave, Toffler argues that the changes in production systems in the history of humanity have caused paradigm shifts, leaving a huge impact on the societies of their time. Naming these paradigm shifts as “waves", Toffler states that the ways people think, speak, work, live, as well as their set of values, and morals have altered with each wave (Toffler, 1980). As all these alter with time, so does the language. Thus, the ways people describe their professions also change through time, as well as the structure of the profession itself. According to Toffler in his time of writing the book, humankind has gone through two major waves and is currently undergoing the third one. These waves are:

| | |
|---|---|
| *First Wave* | The introduction of the settled agrarian community formed after the Neolithic Revolution, replacing the hunter-gatherers. Emergence of the first true society with a devised program amongst people, thus the emergence of professions. |
| *Second Wave* | Industrial Age society formed after the Industrial Revolution, emphasizing concepts such as centralization, standardization, mass production, mass consumption, and mass education. |

| | |
|---|---|
| *Third Wave* | Post-Industrial society, people of the Information Age. Can be considered as the times we are living in, depending on what part of the world we are living in. |

However, these waves do not necessarily mark a complete transformation of the societies around the world. Due to the varying spreading speed of the new production systems across different societies, it is possible to see societies belonging to different waves, societies in progress of adapting to a new wave, or even societies belonging to multi-waves.

This thesis aims to reflect the progression of the architectural profession and project some ideas on the architect and the architecture in the Third Wave / the Information Age. In order to investigate the transition from arkhitekton / *the craftsman* to contemporary architect / *the creative director*, it is essential to observe what paradigm shifts the profession has gone through. Once the different eras in the history of architecture is corresponded with Toffler's suggested waves, it is possible to observe the changing roles of the architect.

However, it is not possible to compose the role for the new architect based solely on observing the status quo, and the precedents. Although paradigm shifts affect our lives in every aspect, they do not affect everything at the same speed. The aspects we relate with in a very intimate way tend to have a higher threshold for being affected by paradigm shifts, compared to others. Dwelling habits are amongst the intimate values for us and we tend to act conservative against groundbreaking changes. Architecture, the field that is most concerned about creating artificial habitats and providing dwelling, is one of the fields where the effects of paradigm shifts are observed later, due to this conservative behavior. Thus, rather than looking retrospectively only into the profession of architecture, we should also look at other fields where the effects of the new paradigm have already established its roots firmly and consider their possible reflections on architecture.

What better place to observe the effects of the new paradigm shifts on people, other than to observe what the essential part of the existing paradigm has gone through? According to Toffler, the production systems triggered by technological advancements have caused the most drastic changes to societies for all ages as he classifies societies based on their production systems. Thus, by looking into the changing production systems, we can speculate more on the contemporary architect. Transformation into to the First Wave was possible by agrarian revolution, while the Industrial Revolution enabled the transformation into the Second Wave. Toffler argues that with the advancements in the technology, people will move beyond mass production into customizable products in his first book, *The Future Shock*. However, he had foreseen a complete personal production system as the paradigm shifter. Seventeen years later (1987), Stan Davis would re-visit the phenomena in his book *Future Perfect*, with an emphasis on the in-between state of mass-production and full customization. He would name it “Mass-Customization”, yet B. Joseph Pine II would actually fill the meaning of this ambiguous production system, the step in between the Second Wave and the Third Wave; the production system that relates to the contemporary society the most.

As we are in the transformational phase into the Third Wave, it is vital to comprehend the existing values introduced by the Industrial Revolution, as they will be challenged with the arrival of the new production system. Concepts such as standardization, specialization, synchronization, concentration, maximization, and centralization (Toffler, 1980) replaced the previous paradigm introduced by the agrarian society. How will/did these values glorified by the Industrial Revolution adjust in accordance with people’s demands as we transform into the Third Wave society? What is the role of mass-customization in this change that affects us all?

Mass customization has aroused much curiosity when it was first theorized, as the name suggested what many conceived as a paradoxical improbability back in the day. Main question is; how could a production method could be standardized, yet be customized for each user? There have been several examples in most of the service sectors and design fields, yet it is extremely rare to see it applied in the field of architecture. Can architects employ this new method in the field of architecture? Can architecture be mass customized? After all, architecture has always dealt with customization in every scale, from design phase to the end-user phase, or with standardization in the building element scale. Is it possible to have hybrid results with mass customization?

This thesis will try to answer these questions, without focusing too much on any of the issues as it is possible to discuss each issue itself in separate theses, yet it is much more essential to have a comprehensive holistic approach for further research in this groundbreaking phenomena.

Without further ado, let us start being acquainted with the waves of Alvin Toffler, as we match them with architectural eras to understand the role of architecture and the architect.

# 2. WAVES

## 2.1 Corresponding Waves

### 2.1.1 Pre-Wave

Although it has been six million years our evolution lineage split from that of the chimpanzee, only little significant happened until 20,000 BC, as people continued to live as hunter-gatherers. Even before the emergence of any kind of production system associated with the waves, humankind knew of ways to protect itself from environmental factors relying on natural formations such as tree barks and caves as shelter has been one of the utmost needs for the living, especially for those as fragile and sensitive as humankind. Heidegger hints the importance of shelter that has reflected on the language by drawing a correlation between *bauen*, *buan* and *bin*[4] (Heidegger, 1971), stating that the act of dwelling is indispensable for human's being on the earth.

If the act of dwelling is of such vitality, then why has there not been a progress in terms of architecture for millions of years? The answer lies in global warming, increased capability of using his limbs, and technological advancements. Only with the end of the last Ice Age near the year 20,000 BC, our grand ancestors' priorities in surviving shifted. The eventual warming of Earth in a period of another 5000 years offered new choices. Increased variety of vegetation, and milder climates encouraged them to come out of their caves and explore the ground for improved life qualities. As they became more proficient with their hands and had more experiences with the materials around them, advances in tooling were inevitable. The history of humanity would dramatically change, triggered with the discovery of the concept of growing and gathering planned crops, farming. By 5000 BC, many people throughout the world would live by farming (Mithen, 2003). This would mark the transitional period to the First Wave.

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[4] *German:* building/dwelling/am (to be, imperative from *bis*)

### 2.1.2 First Wave

Alvin Toffler's First Wave covers the time from 5000 BC to the beginning of Industrial Revolution (1650-1750).

From 5000 BC onwards, more societies transformed into agrarian way of living, some of them merged and formed greater groups, eventually transforming into permanent settlements. The permanent settlements would grow to be the first established cities in the early times of this period. As people started living in the cities, a much more sophisticated organization was in dire need. Since there were more people living together, they could share the workload. Not everyone had to be a multitasked anymore. Because of a better sense of organization required to live in harmony in these settlements, people chose to hone their skills they were comparably adept. Humankind was introduced to the term "efficiency".

It is possible to claim that the idea of profession emerged with the cities (Mithen, 2003). The birth of *arkhitekton*, and the concept of architecture coincides with the time people settled down. First examples of architecture would be houses addressing the basic need for shelter built by users themselves or by specialized builders, making use of the available materials processed by the local carpenters. Early builders were self-taught. Architecture was part of the things people did as part of their daily routine, as no one was specifically trained to become experts on the topic since there was no need for a greater organizational approach to housing demands. Being proficient in building was a side job for most of the carpenters. Dubbed as "Vernacular Architecture", even today a considerable amount of the buildings across the world is built this way. Even though vernacular architecture can be considered a branch of architecture, this thesis will not focus on the subject of vernacular architecture, as it is impossible to link this concept to the profession architecture[5]. In majority of the housing works, client was the architect.

[5] Paul Oliver, in his book *Dwellings*, offers the following simple definition of vernacular architecture: *"the architecture of the people, and by the people, but not for the people"* ruling out any kind of professional help in vernacular architecture. As it is against the nature of vernacular architecture to be linked with professionals, it is better to avoid comparing it with different stages of the profession of architecture.

However, as people’s social skills developed ever increasingly through increased interaction by living in the cities, a new problem had risen. Cities now required larger spaces for people to socialize, and address mostly their religious, but just as important bureaucratic, judiciary and militaristic needs. However, one of these needs proved to be challenging for the first architects, which was to provide houses for deities (Kostof, 1977). This was no easy task as a small mistake could cause the gods’ fury, and the houses for deities had to stand impressive to please the gods. How could a mere mortal (no matter an architect or not) come up with a design to please the gods?

He simply could not.

The highest representative of divine authority, which meant the king or the head priest, could only receive this task on behalf of all people. Kings were supposed to carry this duty for the gods’ blessings in return, acting as the builder for his divine client. In practice, king replaced the gods and the architects replaced the kings.

In the beginning, architecture was a part of the multi-disciplinary innovator of the ancient times. For example Imhotep, the architect of the Pyramid of Zoser in Egypt, was also a scribe, an astronomer, magician and healer (Kostof, 1977). Education of the architect in Ancient Egypt was closely tied to the priestly class, as all education was associated with the priests. Exceptional architects passed their secrets from one generation to another, and they used the “master builder/overseer” as title. They would not necessarily put their physical efforts during the construction phase of the project, but rather contribute with their knowledge and experience (Kostof, 1977), setting themselves apart from the laboring class of craftsmen.

Along with temples and monuments, the need for other public buildings such as baths, judiciary courts, and military barracks had arisen. There was a greater demand for people trained specifically for these purposes. The rulers of the nation or a city committee commissioned the handful of architects in the Ancient Egypt, Greece and Roman times for overseeing the building process of these public works. In addition to civic constructions, the elite families would employ architects for the supervision of construction of their private villas, promoting their wealth. In the meantime, this was empowering architect’s status amongst other professions.

The profession branched out in order to address these issues. In *De Architectura*, Vitruvius classified architecture in three branches; design of public and private buildings *(Aedificatio)*, constructions of sundials and measures of time (*Gnomonice)*, and engineering for military defenses *(Machinatio)* (Pollio, 15 BC), but essentially all architects had to be proficient in all three branches. Vitruvius argued that architecture is much like science, as it had to have both theory and praxis. Architects could be from various backgrounds and could vary in the positions they worked in. He argued that apprenticeship to a master was indeed the best method for anyone who wanted to be an architect, as it mixed hands-on experience with important knowledge passed on from one generation to another thus addressing *theoria*, *poesis* and *praxis*[6].

With the formation of *collegiums*[7] in Roman period, builders were represented under one body and now they were officially recognized as people with profession (MacDonald, 1977). Emergence of these professional bodies established an inter-professional contact for all artisans, whom we would classify separately as architects, engineers, carpenters and builders in modern times, as they were part of the same guild since the line between each profession was blurred.

Moving into the Medieval Age, guilds would transform and builders would be represented as carpenters, but they would retain some of their power. Guilds, an organic continuance of the collegiums, were the dominant body in the world of professions throughout the Medieval Era, and they favored apprenticeship as their method of passing valuable knowledge from one generation to another. There were different levels for professionals. Apprentices started their trainings with a given master and in time, would upgrade to journeyman level, where they could work for other masters and earn a decent living. Upon completing a masterwork, and getting the approval from all members of the guilds, a journeyman or an apprentice (skipping to be a journeyman) could become a master craftsman.

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[6] Aristotle suggested that there are three fundamental, basic activities of any man corresponding to three different types of knowledge: theoretical, poetical, and practical.
[7] Early guild-like formation in Roman Empire

As religion was the dominant factor of the Medieval Era, Church had a great authority on almost every aspect of daily life. As Church had greater powers, one that often exceeded the king's, it replaced the city commission and the rulers as the client. Even though the way of worship has altered, the ultimate client had remained the same. The Church, in the name of the god, commissioned buildings of certain scale, which needed the supervision of architects. However, God's image of the ultimate creator contradicted with the creator image of the architect. Thus, the church chose to employ architect via guilds, without giving a particular importance on the knowledge-contributing architect, erasing architect's prestigious view from earlier times. Of course, there was still an overseer architect, playing an essential role in the organization, but he would not be credited as much, compared to his precedent colleagues in Ancient Egypt and Greece. William Morris summarizes the relation between the overseer architect and other builders as well as the spirit of the guilds as follows:

> *"…through these men he must work, it may be of lesser talent than himself; that is as it may be and matters not, but at any rate men of divers aptitudes, one doing this work, one that, but all harmoniously and intelligently: in which work each knows that his success or failure will exalt or mar the whole; so that each man feels responsible for the whole; of which there is no part unimportant, nor any office degrading: every pair of hands is moved by a mind which is in concert with other minds, but freely, and in such a way that no individual intelligence is crushed or wasted"* (Morris, 1969)

Church was giving importance to the team spirit, or rather the spirit of the faithful mass, as they would have preferred to call. Starting from the 15$^{th}$ century, the changes and questioning of the Church and the rise of the bourgeois would reflect on the profession of architecture. Renaissance advocated empowering man, and only with Renaissance, architects really came to take upon the role of the creator (Saint, 1985), marking architect's distinction from the builder as well as indicating the dawn of a new paradigm for the profession.

Renaissance Era can be considered a transitional period occurring between the first and the Second Wave, as mercantilism emerged, providing an alternative to the agrarian way of living for the society. Although not a production system, it certainly had an impact on the society, as it later on provided the necessary wealth for the entrepreneurs of factories in the Second Wave and accelerated this transition. The era firmly established roots and the necessary connections for the upcoming architects to be able to transform the profession.

With the arrival of the Renaissance, architect’s role would be redefined in a way that has closer ties with the definition of architect of today. Leopold D. Ettlinger defends the idea that architecture was not a recognized profession until the Renaissance, and only then on it would have its clearly defined place within the trades (Ettlinger, 1977). This newfound identity of profession of architecture needed further refinement for distinction amongst similar trades. Architects would become to be known as the set of professional and social relationships he would have contact with such as the patron, the workmen, the administrator and officials of the building program; further separating himself from the mason and the carpenter, trying to make a social distinction by striving to further present himself as the practitioner of a Liberal Art (Wilkonson, 1977).

In Alberti’s ideal of architectural harmony – the design to which nothing can be substituted for without ruining it- required architect to be responsible for every part of his building; architect was a designer and he did not necessarily have to have a role in the construction phase. Building upon Vitruvius’s method for studying architecture, he would accept the Classical Theory, which meant experience solely on the site was not enough, but rather architecture was something to be studied. Architect was free to design for any building material and to use any technical device that would make his building stand (Kostof, 1977). Alberti made a clear distinction between the architect and the builders, assigning their respective roles in the design and construction phases of a building.

Even Church would change their way of employing architects via guilds, they would rather employ architects directly based on their skills. Also thanks to the emerging bourgeois class and their keen desire to accentuate their wealth, architects’ client base would grow again to cover private housing projects.

### 2.1.3 Second Wave

According to Toffler, Second Wave spans from the beginning of the Industrial Revolution to the Post-Industrial era of mid-20th century. Behavior of the Industrial Revolution reflected on the nature of the professions. As higher efficiency was the main aim through mass-production, everything had to be standardized in order to minimize the losses. This standardization process accelerated throughout the Second Wave, reaching its peak in the first half of the 20th century. In order to observe the transformation of the profession of architecture throughout the Second Wave, it is better to focus on the nations that were first to industrialize such as the United Kingdom, France, the United States of America, and Germany as it was the architects of these countries to face the new challenges first.

Renaissance had shown signs of a new era for the architects. These signs would become ever clearer in the 17th century. During the 17th century, English architects tended to belong to one of two classes as the distinction between the architect and the builder grew apart. First group consisted of talented amateurs with architectural proclivities with little to none hands-on experience and the other group consisting of building craftsmen generally masons or carpenters by background (Saint, 1985). John Evelyn has further classified the builders into three main groups (with the fourth type, if we are to include the writer architect); *architectus verborum*; *architectus ingenio*, *architectus sumptuarium*, *architectus manuarius*[8] (Crinson, 1994). This definition indicates that the architect started working as an intermediate agent between the client and the builder, as it became architect's business to conduct the design and estimate, while directing the work.

The number of *archiectus manuarius* (architects with craftsmen qualities) outnumbered the others significantly as there was more demand for simple housing. First group tended to be commissioned with the design of churches and public works. However with the industrial boom in mid-18th century, tables turned. Rapid migration to cities meant demand for vast amounts of housing that was impossible to be supplied via commissioning only the builders. These craftsmen simply were not

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[8] First group represented the architect skillful in the Art of Building, responsible for the design process; the second group was responsible for providing the financial means for their construction, and the last group represented the craftsmen and the artisans, who carried out the actual building process.

familiar with the scale of some of these projects. Big scale housing projects were now being undertaken by *architectus ingenio* as well, who were considered rather amateur-spirited compared to *architectus manuarius*. However there were very few of them, and they were also occupied with other jobs such as surveying the land for future settlements, leveling, etc. (Saint, 1985). The profession had to redefine itself under the guidance of the new paradigm to accommodate the needs.

Pupilage system emerged in England in the early 19$^{th}$ century, with the decline of the guilds. Gradually, the social status of the architect was raised, codes of practice were established and professional ethics began to be sketched out. First professional institute for the architects was established in 1834, which would provide first steps to the modernization of the architectural studies (Crinson, 1994). Its main aim was to draw a distinct line between the architect and the other specialized ranks of the building industry, protecting the architect from misunderstanding of the profession classifications and a possible competition between the architect and others.

Increased complexity levels of the projects favored the architect over the builder as architects were more experienced with projects requiring higher degree of coordination. Although builders had more hands-on experience with the building process, architects of this time gained more importance compared to the builders. It was a situation comparable to that of the Ancient Egypt and Greece, only this time the architects were comparably more in numbers, not just limited to a handful.

Although architects started to be commissioned with residential works outside the elite's domain, builders were still undertaking most of the housing jobs. Even as the number and variety of jobs had risen significantly for the architect, some architects were worried that with the increasing number of colleagues because of the mass-education system, a concept that has emerged with the arrival of Second Wave, there would be a fierce competition. For some of them, they had to set themselves apart from the builders and thus the idea of art in building as the special province of the architect became more conscious and widespread between about 1820 and 1850, as a means of professional self-defense during a period of adjustment and change in the building industry. In the second half of the century, things became easier: the industry settled down, areas of professional responsibility became better defined, and architects found it easier to make a living (Saint, 1985). Dedication to distinction was the main reason the Arts and Crafts movement found a huge support from the English architects.

John Wilton-Ely also attributes the effect of industrialization on the transformation of the profession of architecture. He claims that the formation of the architectural profession in England is intimately bound up with two major intellectual and social changes over the past four centuries—the transition from medieval to modern processes of thought and the shift from an agrarian to a capitalism-based society through the Industrial Revolution (Wilton-Ely, 1977). Changing of production systems due to Industrial Revolution has triggered a paradigm shift.

Mass-Education trends of the Second Wave would further affect the architectural schools established in this era. The Polytechnic schools would be the basis for the Arts and Crafts schools in England (Crinson, 1994). In the meantime, across the Channel, similar transformations were easy to spot. Combined with the catalyzing effect of the French Revolution, Industrial Revolution rapidly transformed the country. Paris, as France being a bureaucratic nation state, would be exposed to these transformations the most. Effects of L'administration des Bâtiments Royaux[9] would linger to influence the organization of the architects (Wilton-Ely, 1977). The Haussmann renovation plan of Paris would employ a vast amount of architects, changing the face of Paris while keeping in touch with the soul of the Revolution. Drawing similar tendencies with its English counterpart, the Beaux-arts schools would have a deep impact on the architecture scene of the 19$^{th}$ century, and continue to be the leading educational system until early 20$^{th}$ century. Many architecture students would flock to Paris from all parts of the world, in the hopes of learning creative eclecticism. One of the school's ultimate purposes was to raise the status of the profession. Beaux-Arts educational system would name an era of architects and would adopt Arts and Crafts into Art Nouveau[10].

On the other side of the Atlantic, things took off in a different way. As architects in the old continent gained more importance, being a pupil in an architectural office was something of importance in Europe. However, due to its vast amounts of natural resources and rapid industrialization, America was desperate for more factory

[9] Royal Building Administration
[10] Further details are discussed in the next chapter, Comparisons.

workers or craftsmen rather than a specialized workforce. Where factories provided wages for even unskilled labor, apprentices to architects received no wages in offices, but they were rather provided with food, clothing, and lodging (Woods, 1999).

Back to Europe, effects of industrialism were sweeping the continent as Germany and Italy were the last countries to catch up with the wind due to their late unifications into nation states. In order to reach England and France's level of industrialization, Germany had to put an extra emphasis on the building of the nation. In Deutscher Werkbund conference of 1914 Hermann Muthesius proposed that the main task of the architect should be to evolve standard building types for the new nation (Saint, 1985), for Germany to develop itself rapidly.

By the beginning of 20$^{th}$ century, industrialization had matured and found its new body under the name Modernism. Modernist Era can be considered the peak point of the Second Wave. It was the time where concepts such as mass production, mass consumption, mass education, standardization, and centralization reached their utmost importance.

We are all too familiar with the fathers of Modern Architecture: Le Corbusier, Mies van der Rohe, Frank Lloyd Wright and many others. They were amongst the architects to experiment and first make use of the newly developed or standardized and industrialized building materials. Due to the scale architecture has to deal; people were hesitant to use these industrial materials in new ways. However, pioneering works by these masters finally revolutionized the architecture. They would wage a fierce assault on their colleagues and their old methods. Le Corbusier would be considered the extremism of the new objectivity in architecture. He would defend that modern technology and method should absolutely determine visual form (Saint, 1985), and Arts and Crafts had no place in the "real architecture". Tension between two sides would escalate as architects had to choose their sides. They would either be part of CIAM[11], or they would favor the methods of Beaux-Art tradition.

Modernist architects would rebel against the methods of the Beaux-Arts. Walter Gropius would claim that the medieval workshop is the ideal learning environment, providing students with a guild spirit, linking artists and craftsmen devoted to

[11] Congrès International d'Architecture Moderne-founded in 1928 and disbanded in 1959

expressing a shared spirit, and becoming a community. As he became the head of Bauhaus, he would state that the "ultimate aim of all visual arts is the complete building" (Crinson, 1994) although architecture was not part of the school's curriculum in the founding years. Bauhaus has been a pioneering school in many fields, leaving a grand legacy. It has always aimed to have an innovative architecture study.

A common characteristic amongst the architects of the Modernist Era is their individualistic behavior up to the degree of solipsism. Fictional character Howard Roarke in *The Fountainhead*[12] is a perfect portrayal of the modern architect. Possibly this symptom was developed by architects during the time they had to reject the Beaux-Art methods, as they had to struggle to find their own way amongst all the harsh criticisms received. This trending individualism of architects peaked with Modernism and Frank Lloyd's Wright career can sum up an era of individualism most evident in the Second Wave architects. A perfect example to the architect / client relationship would be from Frank Lloyd Wright. Known to be very notorious with his relations with clients, he was once asked how he convinces his clients for accepting his designs. With an extreme self-confidence he answers as;

> *"...I hypnotize him. There is nothing as hypnotic as the truth. I show him the truth about the thing he wants to do as I have prepared myself to show it to him. And he will see it. If you know, yourself, what should be done and get a scheme founded on sensible fact, the client will see it and take it, I have found."* (Wright, 2005)

As architects' individualism increased by day, they grew introverted, alienating themselves. Despite its revolutionary start for the profession, Modernism fast lapse into a mere matter of style or superficial philosophy, with the disastrous environmental consequences (Saint, 1985). Ironically, architect's ego would run in plain contradiction with the forces acting on the profession of architecture he would experience during his lifetime, as the role of the individualistic designer gradually faded away. Partnerships, with intermediate tasks specialized on each specific subject essential for the completion of a job, proliferated. As the public sector grew, and the complexity of the building vastly increased, participation from engineers during the process was expected as well as legal experts to whom "creativity" could be barely ascribed to (Saint, 1985). Fully fledged effects of the Second Wave work

[12] Refer to Ayn Rand's bestseller book and the adopted film version.

ethics such as specialization, centralization and synchronization became most evident.

The complexity of architect / client relationship becomes most evident in this era, after all, who is the real client? Is it the patron that has tendered the job to the architect, or is it the end-user that will actually use the building and the architect has no tangible knowledge about? This is a question that still pursues most of the architects, as often both parts' benefits contradict with each other. It is either about maximizing the profits for the contractor through over-standardization of the building design while risking the content of the end-user, or providing tailor-made spaces for end-users while spending too much of the capital the contractor has invested in the project.

### 2.1.4 Third Wave

Alvin Toffler argues that by the end of Second World War, world has begun to receive signals of a gathering Third Wave, based not on industrial output but rather informational output (Toffler, 1980). Third Wave is often dubbed as the Information Age, as much of the importance is put onto knowledge, not physical output. Toffler argues that this era will mark the return of humanistic values, as the era aims a world composed of de-massified media, interactive communication, non-standardization, and customization, as opposed to the values of the Second Wave.

Without any doubt, Modernism was the dominant style in the field of architecture throughout the 20$^{th}$ century. Although we are still morphing into the Third Wave society, there have been some changes in architecture already. In the latter half of the 20$^{th}$ century, some varying key issues such as environmental / sustainable design, cradle-to-cradle design philosophy, high-tech design, and design approaches based on phenomenology have affected architecture as a response to strict modernism, which has become inattentive to the latest changes, to the environment and the users.

Contemporary architects have sought an alternative to the Modern starting from the design process itself, rather than cosmetically changing the final product. As they could employ much more processing power with the advancing technologies, they could feed from much more raw input in a feasible way. Driven with the increasing importance on processing the input, Patrik Schumacher named the new phenomena as *Parametricism*[13].

According to Patrik Schumacher, the new style

> "*…succeeds modernism as a new long wave of systematic innovation. The style finally closes the transitional period of uncertainty that was engendered by the crisis of modernism and that was marked by a series of short-lived episodes including Postmodernism, Deconstructivism, and Minimalism. Parametricism is the great new style after modernism. The new style claims relevance on all scales from architecture and interior design to large scale urban design."* (Schumacher, Parametricism - A New Global Style for Architecture and Urban Design, 2009).

Parametricism has its roots in the digital animation techniques of the '90s. These animations made use of behavioral systems that were mimicked from nature, in order to give a "natural feeling" to the animations. Architects can employ similar methods in the design process in order to address complex issues such as crowd management through simulations, animations and form-finding tools. It confronts the strict top-bottom dictations of the modern architecture design, providing a bottom-up approach.

In order to get a better grasp of the difference between a parametric approach and a modernist approach, one can focus on the way they envisage urbanism. In The City of Tomorrow, Le Corbusier contrast man's way with the pack-donkey's and claims that with the advent of straight line and the right angle, man conquers nature (Corbusier, 1931). He rejects, and pities the medieval city and favors the straight lines in the grid Roman cities. According to Schumacher Le Corbusier's limitation does not lie in his insistence upon order, but rather his concept of order limited only to classical geometry. (Schumacher, Parametricism - A New Global Style for Architecture and Urban Design, 2009). Much like the paradigm shift from the

[13] While personally I defer naming the new approach to avoid the strict barriers attributed by styles(–*isms)*, various names have been suggested including Neil Leach who prefers to name the new trends in architecture as New Materialism.

Newtonian Physics to Quantum Theory, one cannot assume there is an ultimate solution to every question, as the complex behaviors of subjects require an intricate approach[14]. Le Corbusier could not test it, but thanks to the advents in the computational power, alternating methods can now be analyzed and discussed during the design process.

In this transitional period, we see that the pioneering effect of the schools have been greatly dampened by the standardization effect of the mass-education. Even the effect of Bauhaus has been greatly reduced while making the "Bauhaus education" available and accessible to everyone. While it has certainly raised the average, its pioneering role has been replaced by the contemporary architectural offices, as these offices were more apt to change themselves according to the new paradigm, compared to the schools. A critical review in the late '80s on the issue is as follows:

"... to be fair, their problem is a difficult one: the widening gap between the schools and contemporary architectural practice, the diversity and complexity of which goes far beyond the experience of the majority of practicing architects, makes it seem practically impossible to prepare students adequately. " (Gutman, 1989)

Let us look more closely at the architect, who usually will be the prey of economic forces which he cannot significantly influence (Saint, 1985) no matter who the client is, nor the time.

[14] The Complexity Theory, which has its roots on the Chaos Theory, suggests that we cannot have deterministic results for any experiment conducted, but rather a variety of possibilities. Thus, in complex systems, one cannot have the ultimate answer. *Chance and Chaos* by David Ruelle is a good introductory reference on the subject.

## 2.2 Architect in Transition

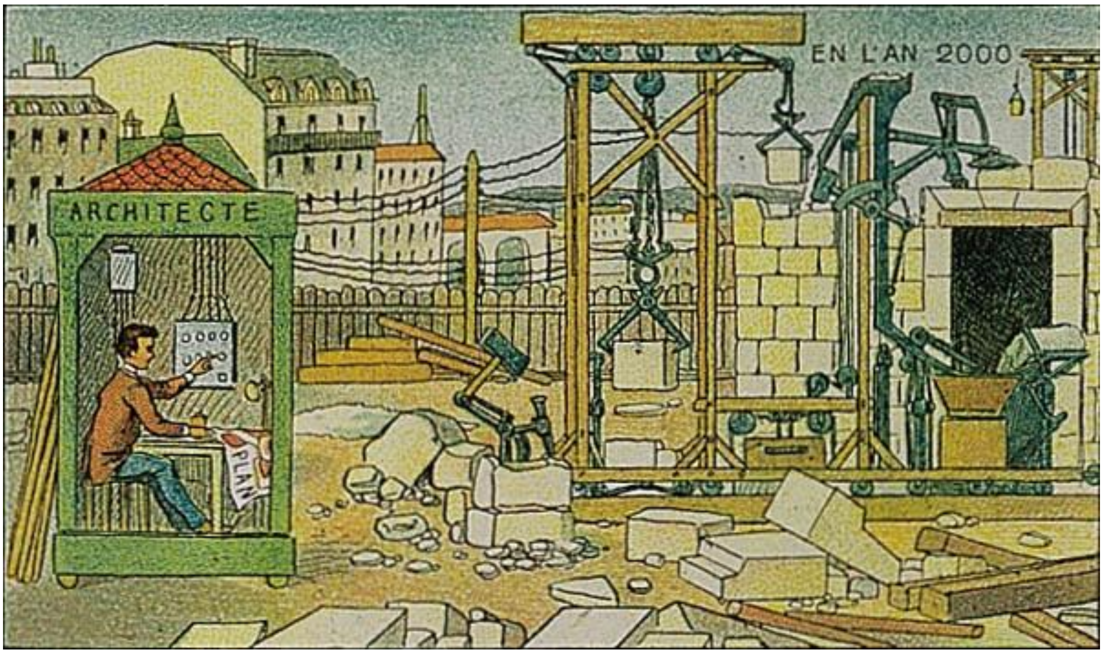


**Figure 2.1 :** An interpretation of the architect of the year 2000, drawn in early 20th century

Amongst us, few are the architect depicted in the figure. Considering the profession's long history, even though we are somewhat acquainted with CAD for some time we have just begun to utilize computer aided manufacturing methods and robots in the building process[15].

Starting as a student, the student architect is offered with a variety of lessons and tracks to choose from, instead of a strict pre-determined curriculum. Compared to the previous eras, the student has a much more flexible training, able to customize the knowledge received. If the educational institution he is currently enrolled in cannot feed his learning appetite, he can always opt for any workshops on any subject offered all around the world. Bearing in mind the advent of the cyber space, one does not even have to be physically present anywhere to obtain any information, he is already being exposed to much more information than one can ask for and obtain.

[15] Robot arms are first utilized in Gramazio & Kohler's elective course in 2006 in ETH Zurich, The Programmed Wall, specifically for building. It is a six-axis robotic arm that could build brick walls precisely

This over-exposure of information may trigger one of the two states for the architect. In the first state, amongst all the information available, architect may choose to focus on a subject of his liking. Just like in the Second Wave, the architect can choose to become a specialist on a subject. Specialization is one of the key codes of the industrial era, and this concept projects onto the professions as well. However, as people choose to specialize on certain subjects, the need for mediating actors rise rapidly for an effective information exchange between specialists.

Thus, the aforementioned excessive information might also trigger an architect to investigate various fields, rather than focusing on one subject. This architect can function as a mediator between all the specialized architects with this holistic approach. Furthermore, the architect does not even have to be constrained to the physical world. With the advent of 20$^{th}$ century, all that was solid had melted into air[16]. Nowadays, all that is solid melts into information[17]. An architect can extend his domain into virtual space, and conceiving architecture algorithmically, making use of the raw data gathered and processing it via new techniques he can become a "trans-architect" (Novak, 2003), taking on different roles during the process, and extending his architect identity.

Yet, even with the introduction of this new breed of architect, there are some things that echo from the past in the identity of the architect. From the Renaissance era to hitherto, architects had retained the role of the creator-in-chief and aggravated under Gropius-inspired trainings, this process has produced authoritarian architect figures, asserting their dominance aggressively over other professions. Although the act we call architecture includes numerous actors, the architects usually fail to regard this fact, placing themselves above other actors, thanks to the identity evolved in the past five hundred years (Tanyeli, 2011). In addition to these qualities, some have added brand values to their works. These branded architects are called starchitects[18].

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[16] Quote from the Communist Manifesto, also used by Marshall Berman to describe the conflicting nature of social and economic modernization.
[17] Marcos Novak can be attributed with this quote.
[18] Star+Architect=Starchitect.

Starchitect's presence is just a reflection of the capitalist order on the profession. It is an absolute necessity, as it is an economic dynamic. As the world grows, so does the number of starchitects. The number of people we could attribute as starchitects in the past has easily folded more than ten times. Considering that, global population will grow by 46% between 2000 and 2050, of which 70% will be living in urban areas; demand for architecture will rise acutely. Eventually this will raise the number of starchitects and multi-disciplinary corporate architectural firms, as they are the groups that are most competitive in terms of brand value or offering the most integrated inter-professional service, a study by Building Futures reveals (Jamieson, 2011).

Public has accepted the status of the architect as having superiority amongst others for a long time, and this status started being questioned seriously only recently, dating back to the second half of the 20th century (Tanyeli, 2011). It is not a coincidence that Situationist International, Archigram, Archizoom, Superstudio and alike has flourished during this time. By eliminating the designer's dominance, and yielding some part of the design initiative to the users, these design collectives aim for democratization of design. They aim the empowerment of the user, not of the designer.

This shift of design initiative has even reflected on utopias. Utopias, which used to be designed and detailed by a certain creator with an ultimate aim, an absolutely top-down process; have turned into intricate ambiguous environments with constant bottom-up approaches of its users as introduced by Constant Nieuwenhuys in New Babylon. New Babylon is a giant framework mega-structure that runs between cities, connecting them via an infrastructural backbone. The spaces in between can be inhabited by Homo Ludens[19] in any way they want, allowing all forms of interaction between the user and the building thus allowing endless possibilities within the framework. Whole building is a giant playground for creative play, as everything *is* a form of play. As Homo Ludens played, varying ambiances and varying spaces would form, generously enriching the experience one would get. Yet, these experiences do not necessarily have to be all positive. New Babylon is a network of bundled relations and win-win scenarios are not always present. New Babylon is about the

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[19] Constant assumes that all work is abolished in future as machines take over for all the production, thus the individual can "play" as he wishes. Hence, Homo Sapiens evolve into Homo Ludens.

idea of non-planning, of continuous indeterminacy. Unlike any other utopias preceding it, there is nothing fixed in New Babylon, no ultimate state of anything. However, one cannot form a utopia as one begins to question the authority of the creator (Tanyeli, 2011). Therefore, it is possible to say that architectural utopias died with New Babylon, all successors are merely dystopias.

As we are in the transformation phase into a new architecture, it is possible to see architects having opposing opinions on who should hold design initiative. In order to comprehend different sides' views on the issue, we should look into another actor of this process who is directly affected by architects' choices: the client.

## 2.3 The User

In terms of supply and demand, profession of architecture has a unique point. In majority of the works, the end user has little to no interaction with the architect, as in majority of the works tendered; a third party (developer or a contractor) purchases the architectural expertise and then markets the product to the end user. As a result, there are multiple actors involved throughout the process. Both the third party and the end users can be considered clients, and most of the time they have contradicting benefits. Third parties' focus on direct financial gain from the product is a competing function with the end user's spatial needs; since every meter cube of space means expenditure. Even if the architect comes up with a solution to satisfy both sides, this may not be sufficient. User's needs may alter through time, or considering the real-estate value of the architectural product, it is possible that an architectural product will change hands during its lifespan. As every user has differing demands, it is almost impossible to come up with an ideal solution to address all problems simultaneously.

Let us first look at the societies of near past, and the present in order to understand the mindset of the user better.

### 2.3.1 Transforming into the Consumer Society

> *The Second Wave has split two aspects of our lives that used to be one up until the Industrial Revolution and this has drove a giant invisible wedge into our economy and our psyches*. (Toffler, 1980)

Industrial revolution created its own integrated system, complete with its own institutions, communication channels and technologies, ripping apart the existing social notions. Main production shifted from fields to the factories, multigenerational households were broken down to nuclear families, rural places and fields were abandoned in favor of urban lives where the factories were located, education of the children was turned over to schools. Overall, there was a great increase in the mobility compared to the rooted down lifestyle of the agrarian communities. Industrial revolution favored values such as specialization, concentration and maximization of labor. These values attributed to Industrial Revolution transformed communities in a very fast manner. Lifestyles were reorganized to match the new era's standards.

Prior to the Industrial Revolution, agrarian societies were mostly self-sufficient. Majority of people would only grow as much crop they needed. Due to natural factors such as the climate, the soil and the range of flora, people could not harvest a wide array of products, but rather the ones they were limited. During the transition to the industrial era, communities dropped their self-sustainability as well as their introverted attitude towards markets and started focusing on things they were proficient at, in return for higher profits that were necessary for obtaining varied goods from other markets.

There was an exchange of goods between communities in the markets of the pre-industrial society as well, yet it is not at a comparable level with the market of today. Majority of the population lived independent of the market. People were both producers and consumers; hence, there was no differentiation of the terms up until the Industrial Revolution. These two words were so fused into each other, that Greeks, the Romans and the medieval Europeans did not distinguish between the two, as they lacked a word for consumer (Toffler, 1980). Only recently, we started to think of ourselves either as producers or consumers. Communities' adoption to the values of the industrial era would make a huge impact on the people and the marketplace.

Market, which was a peripheral phenomenon previously, had moved into the center of our life with the Second Wave. As the purpose of production shifted from use/need to exchange, markets became places where these exchanges took place. Markets were flooded with vast amounts of good of many varieties, granting accessibility to many objects for the masses. The expansion of the market contributed to an acute rise in the living standards of the people worldwide. Thus, the market became an indispensable aspect of our lives.

Every person has a part producer and a part consumer in his body. Two functions have been complementary functions. This duality is present in everyone as a loop that grows with each iteration, as these two concepts are trigger events for each other. We cannot speak of consumption where there is no production, nor can we speak of a production where there is no consumption. However, they have become competitive. Separation of production and consumption also reflected on personalities and on daily life of everyone. Same person who was previously expected to defer gratification, be controlled, be disciplined and be obedient by his family, school and boss, was simultaneously taught to seek instant gratification, to be hedonistic, and pursue individualistic pleasure as a consumer (Toffler, 1980).

Jean Baudrillard examines the social side of consumption in in his early works such as the Consumer Society, System of Objects, and for a Critique of the Political Economy of Sign. Baudrillard roots the production/consumption cycle to the humankind’s natural propensity to happiness, and he believes that happiness is the absolute reference of the consumer society: the strict equivalent of salvation for our times (Baudrillard, 1998). With the dawn of the industrial age, humankind stopped producing directly for our needs, and started to produce more than required. Objects were no longer a symbol for our needs, our salvation.

For modern societies, happiness became the embodiment of the myth of equality as basic needs of shelter, food and clothing were covered and they were no longer a problem. Thus, we would compare people by their level of happiness. In order for happiness to be a vehicle of the egalitarian myth, happiness had to be somehow quantitative. Happiness has to be a well-being standard measurable in terms of objects and signs (Baudrillard, 1998).

What better measurement was there than the products, which had been excessively reachable for anyone by markets, an indispensable part of our lives? The products consumed became the unit of measurement for happiness.

It is appropriate to focus on the individual rather than a macro overview of the society and the ever-growing markets, to further question the duality of production/consumption, and its effects on the client/consumer.

### 2.3.2 Consumer's Psyche

Industrial revolution had an impact on everything. Mass production rapidly increased the supply, and this surplus of products had altered the lifestyles of people. People of this age of affluence were surrounded not so much by other human beings, as they were in all previous ages, but by objects (Baudrillard, 1998). Thus, while investigating the psyche of the consumer, in addition to a person's relation with other people, we also have to look at his relation with the objects that surrounds him.

Objects, as we observed in the previous section, became a unit for happiness. Man has an intricate relation with objects. Object in terms of pure function, materiality, form or color is non-existent; its existence depends on other values in addition to its materialistic values. An object would be nothing by itself if it were not for the values we assign them, or the values assigned to it in relation with other objects, and all the correlations of these values.

Every object must have a materialistic and a functional quality to exist as they reason the product. Aside from its functional and materialistic values, objects may bear the values we allocate them to mark them special. Inseparable from the relation we allocate, object becomes a symbol. Its use value and exchange value almost perish, as it has become a unique object amongst many similar. Significance of the symbol precedes other values. Object becomes a medium of relation.

An object's symbol value loses its symbol status when the exchange is not purely transitive, i.e. when it is immediately presented (as a material of exchange); it is immediately reified into a sign. Instead of becoming a symbol, the object becomes autonomous and intransitive. Thus, the sign object refers to the lacking relation, not an existing relation, and to isolated individual subjects. The sign object is appropriated, its value manipulative by the objects it refers, having a coded difference.

Baudrillard summarizes that an object goes through four main value-making processes, and in order to distinguish consumption, the main unit for measuring happiness, we have to clarify these values, found entangled in an object. (Baudrillard, 1981):

| | |
|---|---|
| *use value* | a functional logic, a logic of practical operations, logic of utility. |
| *exchange value* | an economic logic, an equivalence, logic of the market. |
| *symbolic value* | ambivalence, a value that a subject assigns to an object in relation to another subject, a logic of the gift. |
| *sign value* | difference, a logic of status. |

Industrial revolution eliminated the hurdles in the process of attaining the functional values; the use value and exchange value. As the symbolic value can be attributed only by allocating a relation, perishing all the other values; only the last of these values, sign value, can be strictly attributed to consumption, and thus be a measure. Examples will help us understand these values better.

A wedding ring is a unique object, a symbol for a relationship. Another ring, even an exact match does not bear the same significance, as it does not commemorate the values attached. There is no function in the ring, and the exchange value plays little to none importance in this case, the ring can be diamond or tin. In the wedding ring's case, the essential part is its role. It cannot be substituted, and there cannot be copies of it. It is unique. However, an ordinary ring can distinguish itself from other rings. One can have multiple rings and substitute them. Its material signifies class; it is an accessory, an item of fashion. Overall, it is an object of consumption.

A more relevant example with respect to architecture would be our living accommodations. Semantic nuances in shelter, home, house, and apartment are linked to these values (Baudrillard, 1981). Inheriting an accommodation through patrimony has a symbolic value. On the other hand, house hunting on the real estate market and choosing amongst options such as gated communities, lofts in the bohemian part of the city, or a seaside villa signifies the living accommodation's transformation into a consumable good. Aside from these houses having functional value for their owners, they are also symbols for status.

Jungian archetypes help us understand why people yearn for symbolic objects. According to Carl Jung, unconscious molds our character. Collective unconscious and personal unconscious's combination is who we are. Personal unconscious is the cumulative result of our experiences, which are unique for everyone. On the other hand, collective unconscious is inherited, as they are pre-existing forms called archetypes. Archetype concept is similar to Platonic εἶδος[20]. Archetypes form the basis, which symbols and representations of unconscious emerge. Persona, the process of building these archetypes, is responsible for triggering consumption[21]. The persona is a complicated system of relations between individual consciousness and society, fittingly enough a kind of mask, designed on the one hand to make a definite impression upon others, and, on the other, to conceal the true nature of the individual (Jung, 1928). Persona is a functional complex and it is not identical to individuality. Persona is how we present ourselves to the others.

Sign value of an object and an individual's persona intersect at the notion of representation of the individual. Consumed objects and their sign values help individuals build their personas. Individual defines his persona by picking specific objects amongst a variety of objects carrying different values. Through the set of objects he chooses, he declares the identity he wishes to present to the world. The identity he builds does not necessarily have to reflect his true individuality. As he can represent himself through any object he desires, he can be anyone he wants. At the convergence of persona and sign value, act of consumption gains vital importance.[22] This is how consumption comes of importance. This is how the consumer society dictates life and its routines.

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[20] Plato's theory of Forms asserts the non-material abstract forms, and not the material world of change known to us through sensation, possess the highest and most fundamental kind of reality. Plato states that Forms are essences of things, and they are eternal, not subject to any change, and independent of ordinary objects. Especially the last trait of this theory hints Jung's notion of persona and its relation with sign value. Although the notion of object has evolved from Ancient Greece to our times, we can assume that by being independent of regular objects, Plato refers to objects with symbolic or sign values.

[21] As Persona is the most direct archetype that drives personal consumption, paper focuses on Persona. However, other archetypes also contribute to consumption choices. Hero archetype is also used to trigger consumption. Contrary to Persona's focus on buying motives, Hero archetype is used for marketing purposes. Marketing professionals expects consumers to react to the Hero and be inspired by the hero or develop positive emotions towards the hero, thus being able to market the object of desire through heroes. Marlboro Man, Roland McDonald, Mr. Muscle, and etc.

[22] It is not a coincidence that the word persona has evolved to represent a tool of market segmentation, signifying different fictional characters.

As people give more importance to building their persona, further emphasis is drawn on consumption. As a complementary function, production increases. Production and consumptions' rise triggers economies to grow. Yet, economic growth does not strictly mean an increase in happiness. We cannot guarantee that growth will produce more affluence due to increased amount of objects, and therefore equality; nor it is possible to state growth will produce inequality. Baudrillard expresses that questioning whether growth is egalitarian or not is a false view, as growth itself is a function of inequality (Baudrillard, 1998). Some may argue part of the society who has remained outside of the production/consumption cycle and thus remained considerably poor, will be homogenized as growth affects these parts. Yet it is due to the disequilibrium between the parts of the society that growth may take place.

Growth for long-term equality is a paradoxical loop, as growth produces social inequality, privileges and disequilibria and is dependent on the same values to take place. Disequilibrium will provide a greater growth, which is necessary for consumption of more objects and in return will result in an increased level of inequality. Thus, growth's impact on technology and economy is overshadowed by its impact on social structure. It is an unsustainable circle. As it is an unsustainable circle, alternatives are sought out as an improvement. One of these alternative's roots lie down in the pre-market society of the First Wave.

### 2.3.3 Prosumerism

People of the First Wave consumed what they produced. There was not a division between the notions of production and consumption. Alvin Toffler chooses to call them "prosumer", coining the two terms (Toffler, 1980).

As the purpose of production shifted form use to exchange after Industrial Revolution, most people abandoned prosumer lifestyle, as it was not an attractive choice. One could have access to varied items if he chose to take place in the market instead of consuming what he has produced for himself. Everyone was still a part producer and part consumer, but these two acts were independent of each other. An individual no longer had to consume what he had produced, but was always dependent on others for the objects he had consumed.

One might ask what has happened to prosumers during the Second Wave. Prosumers were vastly outnumbered, and they were non-existent in the eyes of the majority. Economy was defined to exclude all forms of work or production not intended for the market, and the prosumer became invisible (Toffler, 1980).

Excessive consumption lead to an unsustainable loop as argued by Baudrillard. Production and consumption were linked via fragile threads. Increased complexity of the market made it impossible for anything to affect only a part of the market. Any effect on any part had an impact in all parts. Furthermore, these fragile links were not the only weaknesses in the system. As economies had to promote consumption for higher volumes of market activity, there was a high dependence on economic growth. Through reaching more people, one could trigger an increase in consumption and production to accommodate the consumption. This growth turned to be so global that any lag in the growth, or drop in efficiency in key points in the market could translate into a recession or a worldwide financial crisis[23]. Economic growth also had a noticeable effect on a social level, as it was a function inequality[24].

If we look closely to the market, we can see hybrids emerging from the cross breeding of a strictly divided production/consumption cycle and a prosumer lifestyle as consecutive economic crises hit world financial markets. The line that separates producer and consumer started to blur, as the significance of being sustainable rises in the society.

Corporations take measures as well by cutting down expenditures by externalizing labor costs, and through reflecting this on prices, they try to maximize their competitiveness. By increasing the involvement of customers in tasks, the customer takes more roles than a mere consumer. The idea of "Do-It-Yourself" roots here.

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[23] Reader may further look into Subprime Mortgage Crisis as an example of a provisions problem in the United States real estate market first effecting the US financial sector and in return leaving a huge impact on worldwide financial sectors.
[24] Reader may refer to Middle Eastern and North African revolutions of 2011.

An IKEA customer is a perfect example. IKEA stretches the modularization and standardization of an object to the extreme, serving all its products unassembled in a pack with minimum space required. By eliminating final assembly, IKEA cuts considerable manual labor at the production stage, as well as saving a considerable amount in transportation costs of the goods. In return, IKEA reflects these cuts on the products' prices and IKEA customers have to finish the assembly of the products by themselves.

DIY is not limited to goods only; but may include services as well. A pregnancy test can be considered a DIY service, as the user eliminates the doctor's role in the process. Self-service gas station is another DIY service. Ultimate DIY experience starts with a visit to Home Depot and alike. As the relative cost of handcrafts and non-automated services rapidly rise, people choose to substitute professional home-care service with material provided from stores and own skill. DIY transforms the habits of the consumer into prosumer.

The way we started to inhabit our space is also reminiscent that of a prosumer's approach. Most people no longer inherit the space they live through patrimony, and as they choose to live in a new space, they have to pick their own furniture. New model of home dweller: "man the interior designer" is neither an owner nor a mere user. Rather, he is an active engineer of atmosphere. Space is at his disposal like a kind of distributed system, and by controlling this space he holds sway over all possible reciprocal relations between the objects therein, and hence over all the roles they are capable of assuming (Baudrillard, 1996). He does not consume his objects, but rather dominates them and establishes an order amongst them. He has to construct his world, rather than inheriting it. Every choice he makes in the process of constructing his world is primarily a functional one. Dweller is more active as a designer compared to previous ages.

Prosumerism may cause "de-marketization" of certain activities, or at least alter the market activities of some sectors. Yet it is impossible to say that markets will cease to exist in the near future. Market will continue to influence our lives heavily in the foreseen future. As the human race has been busy for the past ten thousand years establishing a market and the last three hundred years for rapidly spreading it all over the world, established order of the market is a strong one and prosumers can challenge only some parts of it. In order to speculate how prosumerism can affect the market, we have to recap how marketization is possible in the first place.

Marketization is possible through three ways; expansion of the market, increasing commoditization, and increasing intermediaries of distribution channels of goods (Toffler, 1980). We have almost reached an absolute in terms of expansion as we have reached and are connected with almost any society anywhere in the world. Without any doubt, one can think of unlimited amounts of additional goods introduced to the market, but it is at this point that prosumer may affect the most. The hybrid relations between the prosumer and the strict market are complex and many self-sustaining notions of the prosumer lifestyle indeed limits the increase in commoditization. Prosumers would prefer to get personally involved with additional services, rather than paying another professional for a service, he believes he can achieve. Likewise, prosumers prefer a simpler distribution channel of goods and services rather than an elaborate one.

Even with all disadvantages the market has to face in the near future, the market is here to stay. As billions of people are linked to each other via a "not-so-sustainable" social contract and with no paradigm-shifting concept on hindsight, it is impossible to entirely abandon the market. However, market will have to reform itself. People will still be dependent on the market, yet they will not be consumed by the market.

As we are familiar with the market, its effects, and the client of the new era, it is appropriate to observe the concept that has emerged from the hybridization of prosumerism and a strict industrialism, the current phenomena of mass customization.

# 3. MASS CUSTOMIZATION

## 3.1 Emergence

Once considered a paradox, mass customization was anticipated by Alvin Toffler in Future Shock as early as 1970, and named by Stan Davis in Future Perfect in 1987. Stan Davis jokingly admits that mass customization is an oxymoron (Pine II, 1993), a seemingly impossible combination of two opposite production systems. The term foresees the combination of low cost advantage of mass production systems with the advantage of customization of craft production. In traditional practice, companies choose to mass-produce their products in high volume through standardization with little-to-no customer involvement or they choose to produce customized products with a high degree of customer involvement in low volume. Mass customization allows producers to customize at low cost while increasing customer involvement, and allow customers to enjoy customized products at relatively low prices, while being part of the process.

Davis's visionary concept refers to mass customization as the ability to provide individually designed products and services to every customer through high process agility, flexibility and integration (da Silveira et al., 2001). Yet, it lacks the nuance the term has. The phrase has been coined to form a middle ground for two different methods of production; however, Davis's explanation suggests unique products for each user without sacrificing scale economies (Duray et al., 2000). Rather, it assumes the production of fully customized products at lower prices and does not specifically identify the paradigm. Although many authors have defined their own image of mass customization in a similar yet more specific ways, the literature lacks a clear way of distinguishing the practice, partly due to the ambiguous and paradoxical nature of the term. Some have put an emphasis on the use of information technologies, while some have underlined the flexible process or the user experience. In any case, mass customization is a systemic idea spanning from the research and development phase, to production, delivery, sales and marketing including the customer experience. Mass customization is a full-circle system that feeds itself.

Mass customization should not be mistaken for another production system, continuous improvement. By comparing mass production, continuous improvement and mass customization, it is possible to distinguish mass customization from the rest. Companies that are mass-producing are bureaucratic and hierarchical organizations. Production depends on workers specialized in one task, repeating themselves. As a result, high volume, low cost, and standardized goods and services are achieved. There is little interaction with the customer, as customer feedback can be collected only after sales, effective only (but not always) for the next production batch. Fordism is the embodiment of mass production systems.

Empowered and cross-functional teams strive constantly to improve processes in continuous-improvement settings (Pine II, Victor, & Boynton, 2000). Managers act as motivating coaches, putting an emphasis on communications. As a result, low-cost, high quality standard goods and services are achieved that are constantly improved in every generation thanks to the feedback collected in all the phases the product meets the user. Seen dominantly on Japanese car producers after the Second World War, interlinked teams bridge separate functions that interact with each other in a predictable manner. User involvement is as much as mass produced systems.

On the other hand, mass customization demands for total flexibility and responsiveness, as it requires a dynamic network. The process, units and the technology has to reconfigure to give customers what they demand. Managers are rather independent, responsible mainly for the efficient communication between various systems. A horizontal organizational scheme is present, rather than a hierarchical vertical organization. As a result, low-cost, high quality customized goods and services are produced. Users may be involved in various stages of the design, production or the use phase.

Even though there is no single definition for mass customization, all literature written on the subject agrees on two common notions essential for distinguishing mass customized systems. User involvement throughout the process and flexible production via modularity are two essential parts of mass customization. Standardized modules, interchangeable flexible parts that can accommodate different settings on demand while ensuring an economic advantage over crafted customized goods, assure *mass* customization. Customers' involvement and design decisions, creating unique customer experience ensure mass *customization.*

Da Silveira argues that demand for developing mass customized systems can be justified based on three main ideas (da Silveira et al., 2001). First reason is the ability to assess flexible manufacturing and information technologies to deliver an increased variety at lower costs, referring to the main idea the paradigm suggests. Another reason is to reach out to the customers outside of the already targeted segmented markets. As customers increase their demand for product variety and customization at finer details, segmenting the market cannot target all customers. By including the customer in the process, companies gain direct access to customers and their favor. Finally, due to aggressive expansion of the industrial competition and markets as well as the increase in consuming habits, product life cycles significantly got shorter, leading to the breakdown of mass-producing industries.

**Figure 3.1 :** Customized Adidas shoes via miAdidas.

Companies favor mass customization as it greatly enhances customer experience. Yielding part of the product design to the user grants customer freedom. As customers can choose what they demand, possible customer dissatisfaction is vastly eliminated. Although the product goes under a customization process, brand recognition and brand identity is maintained by permanently placing characteristic feats of the company, such as the logo. The three Adidas shoes are easily recognizable thanks to the three stripes placed on the sides. The system allows the user to alter every part of the shoe with different colors and materials (including the logo’s materials), yet the overall design stays the same. User is happy, as he can get the shoe he wants, the brand is happy as it achieves another sale and most importantly, a satisfied customer who is more likely to be a loyal customer.

### 3.2 Classification of Customization

There is a great debate over determining the levels of customization and standardization in the process of mass customization. Instead of defining mass customization by fixing a ratio between these two notions, one should rather place mass customization on a scale and judge each case based on this scale. Based on corresponding various authors definitions, table 3.1 enables us to compare and differentiate projects based on solid criteria.

A product or a service can be developed on a continuous framework. This continuous framework establishes a common ground for us to compare various authors' mass customization visions as we match their observations to these generic levels. Basing their opinions on empirical observations, Gilmore and Pine classify mass customization approaches in four categories as collaborative, cosmetic, adaptive and transparent (Gilmore & Pine II, 1997). Lampel and Mintberg focus on the development of different mass customization strategies. They rank these strategies in a full scale ranging between pure customization and pure standardization, dividing this scale into five; pure customization, tailored customization, customized standardization, segmented standardization, and pure standardization (Lampel & Mintzberg, 1996). Pine emphasizes the production stages and suggests five stages of mass customization according to their production: modular production, point of delivery customization, providing quick response, and embedded customization (Pine II, 1993). Finally, Spira develops a framework with four types of customization; modular assembly, additional custom work, customized services, and customized packaging (Spira, 1996). As the latter two focuses only on a narrow part of the production cycle, we will be focusing on the first two classifications as well as generic mass customization levels.

**Table 3.1 :** Levels of customization (da Silveira et al., 2001)

| MC generic levels | MC approaches | MC strategies | Stages of MC | Types of customization |
|---|---|---|---|---|
| Design | Collaborative; Transparent | Pure customization | | |
| Fabrication | | Tailored customization | | |
| Assembly | | Customized Standardization | Modular production | Assembling standard components into unique configurations |
| Additional custom work | | | Point of delivery customization | Performing additional custom work |
| Additional services | | | Customized services; providing quick response | Providing additional services |
| Package and distribution | Cosmetic | Segmented standardization | | |
| Usage | Adaptive | | Embedded customization | Customizing packaging |
| Standardization | | Pure standardization | | |

### 3.2.1 Generic Levels

To cross reference various mass customization definitions, da Silveira et al. proposes to match various definitions with the continuous framework of production. By referencing various visions with the traditional production line, it is much easier to compare the levels of mass customization described by different authors. Customization level is measured via its position on this framework. Thus, da Silveira et al. states that customization may take place in any of the eight generic levels of production; design, fabrication, assembly, additional custom work, additional services, package and distribution, usage and in the case of no present customization, a pure standardization level (da Silveira et al., 2001).

With a traditional production line in mind, design refers to pre-production planning phase of the product. As design phase is concluded, fabrication phase is resumed. As the name suggests, fabrication is the actual materialization process through mass production. Since most mass produced goods are not produced in a single factory line, but are rather fabricated in modules to be assembled later. Assembly refers to the combination of these modules. Additional custom work and additional services are extra levels the authors has introduced to blend various definitions of mass customization into the product cycle. They are not mandatory steps in a product cycle, but rather secondary. These in-between steps strictly refer to customization only. After modules are assembled, they are ready to be delivered to users. After the packaging and distribution phase, the goods are delivered to or purchased by the intermediary agents or the user. From this point on, goods enter the usage phase of the production framework.

As we are acquainted with the basics of a production cycle, we can focus on users' impact on the final product based on their involvement at any generic level and how authors interpret this input while defining mass customization. Duray et al. also proves that it is possible to identify and classify mass customizers based on two characteristics: the point in the production cycle where the customer is involved and the type of modularity employed for production (Duray et al., 2000).

### 3.2.2 Approaches

In the Four Faces of Mass Customization, James H. Gilmore and B. Joseph Pine II classify customization approaches into four distinct options; collaborative, adaptive, cosmetic and transparent (Gilmore & Pine II, 1997).

In collaborative customization, customers are involved in the process from the early design phase on. Paris Miki, a worldwide Japanese eyewear retailer, started offering its customers to collaborate on the design of the eyeglasses through a system they have developed in 1994. Users are able to customize their eyeglasses through an interactive system named “Mikissimes”. After their picture is taken and analyzed by the system, customer’s desires are put in to be recommended with a lens size and shape. The system projects possible outcomes on the picture taken, and is able to cycle through variations. After collaborating with the optician for technical measurements, users are able to choose amongst a vast array of possible parts to compose unique eyeglasses, which can be produced in as little as an hour.

In the next two decades following the Mikissimes System, more advanced systems have appeared online with the advent of internet. As they are cyber-based, they eliminate the customer’s necessity to go to a defined location for customization, and any locational restrictions. Customers are able to define their design by picking the color, material, and/or additional accessories for their products via an interactive user interface, which also may suggest some designs randomly or based on previous customizations of others[25].

In transparent customization, customers are involved from the design phase on as well. However, the provider does not let the customer explicitly know that the product or the service have been customized for them. Pine and Gilmore gives the example of a chemical company based in Ohio, ChemStation, which mass-customizes a product where most of its competitors would treat as a commodity: industrial soap (Gilmore & Pine II, 1997). By monitoring the demand and supply, ChemStation delivers soap at the right time. Transparent customizing companies take the initiative of customizing the product on behalf of the users.

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[25] Readers may refer to popular sports shoe brands’ customizers such as Adidas’s miAdidas, Nike’s NIKEiD, Puma’s Mongolian Shoe BBQ, and alike.

Contrary to collaborative customization, transparent customization can only be applied to already existing customers. Online retailer Amazon boosts its sale through a similar customization process. The site stores buying habits as well as browsing habits, in order to suggest similar products via its intelligent suggestion system.

Cosmetic customization affects only how a product or a service is presented and/or distributed, and has no effect on the actual product or the service. A customization that is mostly on a corporate level, there is minimum amount of change in the actual product. Even though customizing a product this way is cosmetic as the name would suggest, and consists of a simple re-labeling, it still increases the actual product's value for a third party[26].

According to Pine and Gilmore, the fourth approach to customization is an adaptive customization strategy. A standard, but customizable product is designed to provide users an interactive experience throughout the product's usage. Customization level of the adaptive customized products greatly alter from the rest of the products, as direct personalization is aimed. Interactive lighting systems by Lutron Electronics, Artemide, Phillips and alike provide customers to be adaptive customizers. Aside from preset lighting settings for varying moods, or lighting systems that reactively adjust to their surroundings, users can adjust the lights according to their liking.

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[26] Customizers may choose to aim for a different demographic and may aim to lower a product's value. Such as a supermarket's own brand may choose to provide the same product for a lower price under a different brand identity.

### 3.2.3 Strategies

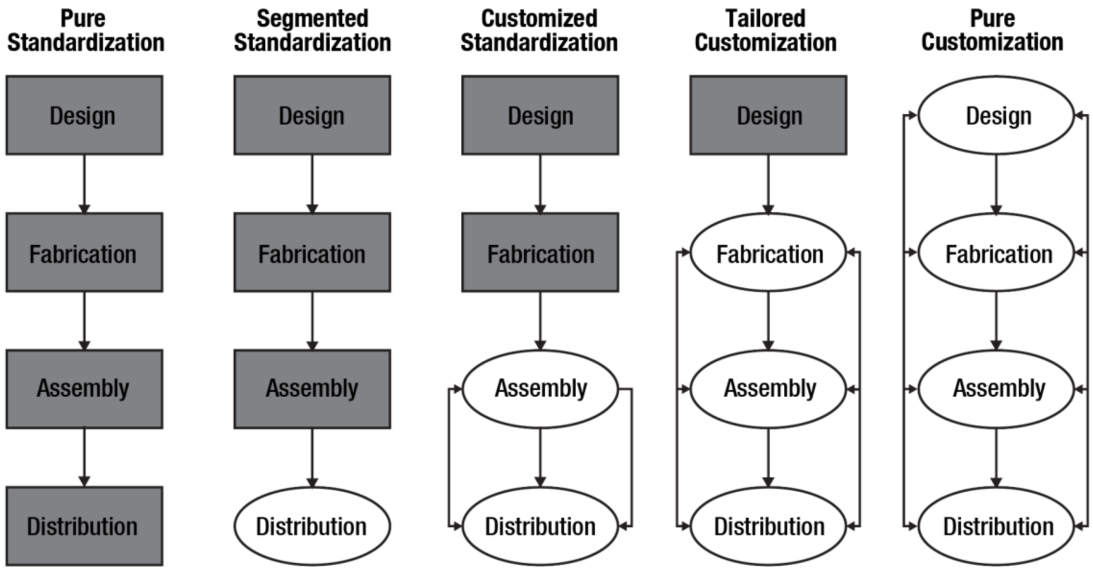


**Figure 3.2 :** Joseph Lampel and Henry Mentzberg's classification of customization strategies. Gray boxes indicate standardization, and the others customization.

Joseph Lampel and Henry Mentzberg classify customization strategies from pure standardization to pure customization. These two notions should not be mistaken as opposites, as standardization and customizatioWn do not define alternative models of strategic action, but rather, poles of a continuum of real-world strategies (Lampel & Mintzberg, 1996). In other words, they are not opposites, but rather two ends of the same phenomena. A product's level of collaborative design can also be traced to this scale.

Standardization is a top-down strategy with fundamental design followed progressively by fabrication, assembly and distribution. On the other hand, full customization is a bottom-up strategy, placing the user to the core of the product cycle. Customization begins with the downstream activities (distribution), closest to the marketplace and may then spread upstream (Lampel & Mintzberg, 1996). These two approaches give rise to hybrid strategies mainly classified into five groups; pure standardization, segmented standardization, customized standardization, tailored customization and pure customization.

In pure standardization, there is no distinction between different customers. Companies take all the decisions in the product cycle until the product reaches the user. Thus, the production flow is very strict. Ford Motor Company's strategy in Model T is the essential example of pure standardization – a car could be any color as long as it was black.

Segmented standardization refers to standardized products with targeted markets. As market researchers analyze different *personas*, buyers are merged into bigger clusters and the products offered are standardized within a range of features. A basic design is modified and applied to the customers, but users are not involved in this process. Segmented standardization is a top-down strategy as the users are only involved in the distribution phase and users have no influence over design or production decisions.

In the case of customized standardization, products are composed according to the user's preference from standardized components. Initial design and fabrication phases are standardized while the assembly and the distribution of the product is customized. This is a very common case in automobile industries, where the customer can modify the car he or she desires through a set of components. Due to the importance given to the modular behavior of this customization, it is also possible to call customized standardization as "modularization" or "configuration" (Lampel & Mintzberg, 1996). The company standardizes basic design, and thus the design of components fabricated, yet the user can compose his or her own product from an array of possibilities. The product is constructed around a central standard core.

If the user involvement starts from the fabrication phase onwards, we can speak of a tailored customization strategy. A tailored suite is an example to this process. The customer is presented a product prototype, and then the product is tailored to fit the customer's needs. Initial design remains the same, but it is altered.

Individualization reaches its peak in pure customization, as the user is involved in the production cycle of the good or the service from the design phase. Relation between the buyer and seller is transformed into a genuine partnership, in which both sides have a great impact on the product (Lampel & Mintzberg, 1996). Megaprojects such as Olympics games and NASA’s Apollo project are purely customized projects. Residential architectural projects where users directly communicate with architects, without the involvement of the developers can be considered as pure customized projects as well.

### 3.3 Concept of Modularity

There are two key elements in defining mass customization approach, customer involvement and modularity. Modularity is a key to achieving high volume, low cost customization (Pine II, 1993), allowing part of the product to be produced in volume as standard modules with product distinctiveness achieved through combination or modification of the modules, thus significantly reducing the cost of production. Standardized modules allow mass produced products achieve a consistent level of quality with repetitive manufacturing capabilities. Modularity is the *mass* customization. It bounds the degree of customization of the product and distinguishes mass customization from pure customized products (Duray et al., 2000).

There are multiple faces to modular design, which can be summarized with the following diagram. These types of modularity can be used separately or in combination to provide a customized end product.

Different types of modularity can be assigned to the phases of the production cycle. During the design and fabrication phase, producers can utilize cut-to-fit and component sharing modularity as modules can be altered or fabricated in these early stages. Component swapping, sectional, mix and bus modularity types can be used in the assembly and use phases, since they depend on manufactured modules’ rearrangements. Modules are not customer specific, but rather combined in accordance with customer specifications.

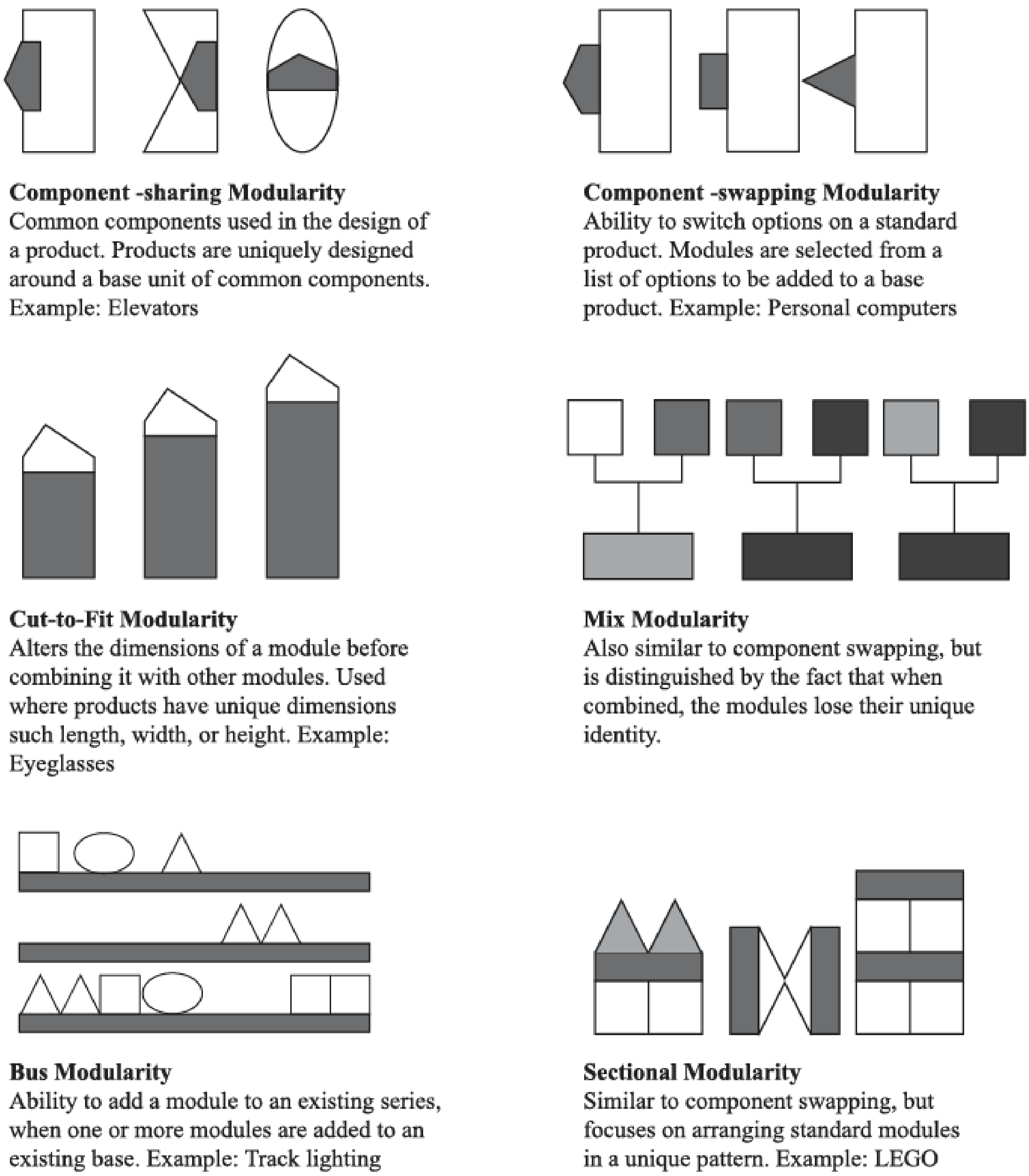


**Figure 3.3 :** Modularity types (Ulrich, K., Tung, K., 1991)

As a result of modularity, product uniqueness is a result of either the combination of standard modules in a finite number of permutations, or the alteration of existing modules into a limited range of products in accordance with user specifications. Standardization process of these modules makes customization of products in large volume at low costs, thus making the product mass customized. Mass customized products create unique experiences for their customers. Let us examine how mass customization differs from varied goods.

### 3.4 Customer Involvement

The other key element in mass customization approach is customer’s involvement in the production phase. Customer involvement defines the customization process in the mass customization approach, creating unique customer experiences with each product.

Mass-customization includes one-to-one marketing, as customer involvement is a necessity. Interactive user interfaces establishes the customer involvement in the process of utilizing flexible manufacturing systems. In ongoing producer/customer relations, the twin logic of mass customization and one-to-one marketing binds producer and consumer together in a *learning relationship* (Pine II, Peppers, Rogers, 2000). The connection between two sides becomes smarter as the two interact with each other, collaborating to meet the customer’s needs over time. The system may even recommend options to customers, as it gets to “know” the customer.

Amazon’s Recommendations is an interactive user interface based on a learning relationship of the user’s habits. The system recognizes you as you login, and based on your past purchases and item browsing stored on the database, system recommends “similar items you may like”. In this case, similarity of items are linked via the database that stores every user’s purchase/browsing habits, drawing correlations between user patterns and matching items based on these patterns. Users do not face a simple interface, which merely lists items on the page. Indeed, through this interface, they are window-shopping with millions of other fellow shoppers all over the world, without even noticing this worldwide interactivity. Shopping has always been a social activity, now it is globally social.

Mass customized products can be classified according to their point of customer involvement in a project. If the table of customization cross-referenced with modularity, four archetypes of mass customization are created.

**Table 3.2 :** Matrix grouping of mass customization configurations (Duray et al., 2000)

| | Type of Modularity | | | |
|---|---|---|---|---|
| Point of Customer Involvement | Design | Fabrication | Assembly | Use |
| Design | 1 | | 2 | |
| Fabrication | Fabricators | | Involvers | |
| Assembly | 3 | | 4 | |
| Use | Modularizers | | Assemblers | |

Group 1 includes both customer involvement and modularity in the early phases of the production in the factory, thus named as fabricators. Level of customization is highest compared to other groups. Group 2 incorporates customer involvement during the product design, yet no new modules are fabricated for the customer, only utilizing the existing module architecture. Customer is involved during assembly and delivery in Group 3, but modularity is incorporated from early stages. As modularity is used earlier in the manufacturing process than when customization occurs, this modularity may be considered component commonality (Duray et al., 2000). Both modularity and customer involvement is factored in the last phase of the production in Group 4. Orders are assembled from a pre-determined set of features only.

Customer involvement in the process determines the strategy required for the production of the commodity, and is often related with the scale and the volume of the product. As the production volume increases and the scale of the product decreases, standardization levels increase and the customer involvement, if there is any, takes place later in the process rendering customers mostly as assemblers. On the contrary, if the production volume is rather low and the scale of the project is big, there is a higher chance for customer to be involved from an earlier phase, often resulting in cases the customer being a fabricator.

### 3.5 Issue of Variety

**Figure 3.4 :** Andreas Gursky's 99 Cent II Diptychon

Although Pine was the first one to explore and describe the mass customization phenomena, he could not set the tone between a person's access to a variety of choices and mass customized systems for users. In one of his examples for mass customized goods, Pine claims that as opposed to the time where there was limited choice for personal care items, increased variety (shampoo for oily hair, dry hair, normal hair, for particular pH balances, for environmentally aware customer, with conditioner, etc.) is a result of mass customization (Pine II, 1993).

Variety is not mass customization. It is, at most, a derivative of mass customization. As explained before, user involvement is a *must* in mass customized systems. Variety of products is often the results of a number of test groups; result of segmented standardization. Variety provides choice for customers, but not the ability to specify the product (Duray et al., 2000). Is having a wide array of products beneficial for the user, as user has the freedom to choose amongst all the possibilities offered to him?

Definitely not.

Opposed to having small amount of choice, variety may be considered luck. However, the transformation of choice in modern life is that choice in many facets of life has gone from implicit and often psychologically unreal to explicit and psychologically very real (Schwartz, 2004). Of course, our freedom of choice still matters, and everyone would opt for the freedom of choice if we were to choose between having this freedom or not. Yet, the cumulative effect of the absurd number of choices for everything in our lives has created a tyranny of small decisions, as Fred Hirsch states, causing substantial distress to the customer.

Excessive number of choice causes people to re-assess their choices, which contradict with the ultimate aim of time consumption. The assessment process almost replaces the actual experience a user gets from the product. We have complicated this process in ways un-imaginable. Consumer review sites, personal experiences told by friends, advertorials, and all marketing related activities drive the assessment process to extremes.

Furthermore, time is not the only thing we have to care about. There is also a psychological effect to good and bad choices. “Bad” choices have more effect opposed to “good” choices, as it is expected from a newly purchased product to perform accordingly to our expectations. As we have more choices than ever, our expectations from products increase, also increasing the responsibility of assessing what we need as well as increasing the chance of choosing an under-performing product increase. Our experience of choice as a burden rather than a privilege is not a simple phenomenon. Rather it is the result of a complex interaction among many psychological processes that permeate our culture, including rising expectations, awareness of opportunity costs, aversion to trade-offs, adaptation, regret, self-blame, the tendency to engage in social comparisons, and maximizing (Schwartz, 2004).

Mass customized systems stand out as a possible response to the burdens of excessive variety. As customer is involved in the production process, he is able to shape the product to match his needs. As opposed to full customization, which he still has to face a wide range of possibilities, modular behavior of mass customized systems restricts the customer to focus. By eliminating the excessive varieties, natural resources can be saved from over consumption, improving the sustainability of the product and its cost-effectiveness.

Now that we are acquainted with the concept of mass customization, let us further observe how this phenomenon applies to architecture, how the architect and the client can benefit from it, and examine case studies.

# 4. MASS CUSTOMIZATION OF ARCHITECTURE

## 4.1 Design Phase

Mass customization of a product may occur in various stages of the production depending on the type and scale of the project, customer involvement, and the level of modularity employed. Same rules apply to mass customization of architecture.

Architects, as the design professionals, have been exposed to the effects of mass customization rather recently as their profession has always required customized solutions. Other building professionals, especially material engineers have been utilizing the new production system considerably for a longer time. Fabrication phase of architectural products has been utilizing an array of production methods in the scale between full customized and full standardized in comparison with the design process. On the other end of architectural services, users have always been customizers with their intimate surroundings.

Following the production flow, we will first examine mass customization in the design phase. Output of the design phase is an informational data for the fabrication of the building. Informational data by itself merely constitutes an architectural product by itself; it is rather dependent on the realization of the project to become an architectural product. For the design to be able to communicate with fabrication; it must be represented in a coherent form. However, the representation of the data, whether in a mechanical or a digital form, is not relevant with mass customization of the design. Design rather relies on processing the data. Thus, the effects of mass customization on the design phase can only be observed by examining the tools employed for the design and the cohesive enabling technologies.

### 4.1.1 CAD

Toffler indicates that the end of the Second World War marks the dawn of the Third Wave. Similarly, Peter Eisenman draws attention to the aftermath of the Second World War while implying architecture was late to catch up with the new phenomenon. Eisenman states that during the fifty years since the war, a paradigm shift has taken place that should have profoundly affected architecture: the shift from the mechanical paradigm to the electronic one. This change can be simply understood by comparing the impact of the role of the human subject on such primary modes of reproduction as the photograph and the fax; the photograph within the mechanical paradigm, the fax within the electronic one[27] (Eisenman, 1992). The new paradigm has transferred the information to the virtual, rendering the hard copy obsolete.

The paradigm Eisenman refers roots to the numerically controlled systems. U.S. Air Force developed the early numerical control systems for the precise and repeatable fabrication of aircraft components in 1940s (Corser, 2010). This system was developed and first used for the aviation and space industry, as they required the precision offered by this numerical control system. Since they were gigantic industries that could invest in the new production techniques, numerical control systems took off quickly in these industries. Advents in digital computers in 1960s enabled the linkage of computer-aided design (CAD) and computer-aided manufacturing (CAM), allowing other industries to utilize the new system. Used in coordination, this system offered beneficial results primarily for the construction of complex products such as ships and automobiles. As the use of computers spread, so did the new technologies. Following decades witnessed the utilization of CAD and CAM technologies in every industry field.

[27] Considering the year of this statement, internet is a better contemporary substitute for fax.

CAD arrived late to architecture, as the initial costs of these systems were too high. Considering narrow profit margins in the industry and architectural projects' uniqueness, this late arrival can be justified. Building industry was slow to adopt the new technologies, except where applicable to produce clear efficiencies in preexisting business process, namely utilizing CAD for the production of two-dimensional drawings (Corser, 2010). Originally, the role of computers in architecture was to replicate human endeavors and to take the place of humans in the design process (Terzidis, 2006). They mimicked the traditional tools of design and were limited to them. The design process has transformed from the mechanical to the digital, however nothing had changed in its nature. Architects continued to provide fully customized processed data for the clients. Only the medium that formed the informational representation had changed, not the method of processing data. Digital systems were used purely for their ease of reproduction.

CAD provided great efficiency, and proved to be a great eye-candy. With the advanced graphics and processing power, last two decades has seen the transformation of architecture from a manually driven tool-based design and practice profession to a computer-driven form based design and global practice. Some starchitects use the computer as a means of marketing and presentation, despite their claims to the opposite. As their names are a brand, their fame is enough to generate desire for the computer-driven forms, justifying the process of generating blobs of utter nonsense in return.

However, conventional CAD is *not* digital design.

In its current method of use by the majority in the industry, CAD is indeed a limitation. Architects are restricting themselves to a limited tool that is just the simple digital representation of their traditional tools. Even compared to conventional models, it had little qualitative effect on design (Kalay, 2004). The architect interacts with a digital sketch, drawing or a model, not the overall design. Indeed, conventional use of CAD can be considered as a tool for architecture of the Second Wave.

Architects who prefer to use conventional CAD systems do not question the origins of the commands they type in, but rather are more interested on the outcome of the commands. As conventional CAD programs adopt tools that are reminiscent of popular architectural feats developed by starchitects and alike with each new release, number of architects who have no idea what they are doing increase dramatically. Increasing number of metaball blob architecture, filleted building blocks in urban design, and especially all voronoi applications are indications of the gravity of the situation.

Using a conventional program and relying solely on its limitations, the designer/architect's work is eventually at risk of being grossly imitated by lesser-devised solutions. By cluttering the field with imitations of a particular designer's style, one runs the risk of being associated not with the cutting-edge research, but with a mannerism of architectural style (Terzidis, 2006). Conventional CAD places architects in a vicious circle of repeating our precedents.

Without a doubt, computers are significant tools that may provide new breakthrough designs by the raw power they possess. Thus, mining the essence of computational approach is of utmost importance.

### 4.1.2 Tooling

With the introduction of CAD, computers replaced manual drafting tools. Connotative notion of tool implies control, power, dominance and skill. However, this is not the case with computers in architecture. Their capacity is often underestimated. Indeed, designers are frequently amazed by processes performed by algorithmic procedures, which they have no control or, often, knowledge of (Terzidis, 2006).

Designers make the common mistake of confusing computerization with computation. Computerization is the direct translation of a mechanical system to the digital environment with minor or no alterations for enhanced efficiency. It is the act of entering, processing or storing information. On the other hand, computation is the procedure of calculating through mathematical and/or logical methods. Computation requires algorithms, a set of instructions given by humans to be performed by a computer.

Actually, computers are not the only tools for solving algorithms. A handful of architects would resort to physical models/tools for form-finding solutions decades before computers were able to handle complex problems or even existed. As early as the beginning of 20th century, Gaudi experimented on arches by hanging chains. Chains represented the load bearing arches. He fixated the endpoints of the chains to a planar platform and knotted the points he wanted different arches to interact. As he raised the platform that the chains were fixated, gravitational force acted on the chains. As the chains found their equilibrium, he could gather the catenary arches required by inverting the chain model.

Another pre-digital computational figure was Frei Otto. Otto founded the Institute for Lightweight Structure (IL) under the Stuttgart University and they experimented with material-aware formational models, which were literally analogue computers. Frei Otto and his team found out that it is possible to find the relaxation of membranes and thus the minimal surface by dipping a frame to soap water. As the frame bent, liquid soap relaxed to the position where the surface tension was zero. They employed this method for the stadium and canopy covers in Munich Olympics ’72.

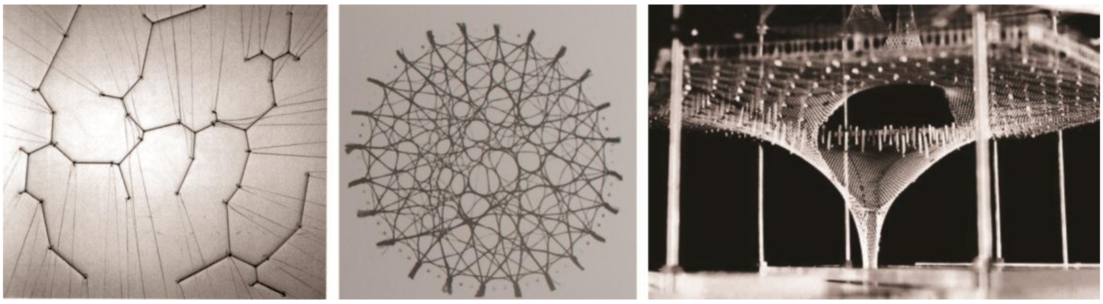

**Figure 4.1 :** Frei Otto’s various manual tools

Frei Otto’s projects went beyond architecture narrowly conceived and into the investigation of methods to observe nature “processually and integrally” (DeLanda, 2004). For computing minimal detours in urban planning, Otto and his team developed a wool thread machine. The machine consisted of a circular frame with wool threads joining every point to the other in the circumference. The apparatus is then submerged in water and lifted, allowing surface tension to bundle the wool threads together. As the tension force is applied equally to the wool threads, the wetgrid of bundled wool threads emerge which resembles the minimal detours.

As the examples ratify, mechanic tooling is very much possible, but the increased computational power of computers favor computers over mechanic tooling. Indeed, computers are nothing but “Idiot Savants” (Oosterhuis, Swarm Architecture, 2003). An idiot savant is a mentally retarded person with remarkable capabilities. They can recite up to the twenty-thousandth digit of Pi, can sketch a city panorama they etched on their visual memory just by a five-minute glimpse, or perform similar activities with no hassles yet most of them have no idea how they do it. They are coded, somehow, to perform these tasks and they do it without questioning or understanding the task. In this sense, computers are powerful idiot savants. They can perform the most excruciating algorithms otherwise impossible to be performed by the mere human beings without a hassle if they are configured for the task (read: coded), yet the designers treat them as simple drafting tools. Processing power of computers has always been primarily used for solving algorithms in every field of science, but majority of designers have opted not to utilize computers for their intended purpose of computation.

In order to cultivate the computational power of the computers for use in the design process, design inputs must be digitized and the design process must be handled in the digital environment. Inputs of all kinds must be digitized and selectively treated as parameters for the design. Necessity for emphasis given on parameters in contemporary architecture was briefly discussed while introducing the architect of the Third Wave, quoting Patrik Schumacher.

Schumacher is actually confused by the grammar introduced with the recent advents in architectural design, as he attributes computing based design strategy as “parametricism”, grouping all different architectures under one “style”. Architects have always designed with parameters, which are inconsistent and varied from one designer to another as the nature of the word implies. Every designer assigns different priorities to different parameters, thus attributing the word “parameter” as a style is an irony, eradicating the flexibility indicated by the notion as he constrains it as a style. However, Schumacher has a valid point. Architects can benefit from the enabling tools as it offers greater flexibility to establish clear design goals and manipulate various design parameters to achieve desired goals through the set of algorithms he has composed.

Parametric design differs from conventional systems. Christopher Shusta draws attention to the difference between conventional CAD and the computational design being on a more fundamental level: decision-making (Terzidis, 2006). Former is a mode of representations; it is purely the digitalization of a thousand year old method. Paper replaced by the computer screen, pen by the keyboard and the mouse. Designs are still conceived as two-dimensional representations, parallel lines intersecting another set of parallel lines. Latter one promotes another way of thinking the design. Instead of channeling an idea directly into form, it promotes channeling an idea into a process and eventually into a form.

In order to effectively employ true digital design and benefit from computational power, architect must know more than architectural design and drafting to channel his ideas. Since computation is the domain of computers, the architect must communicate with computers directly. Architect must be computer literate to turn computer into a tool. Level of control over design rationally increases with higher level of computer literacy. Instead of being restricted to what conventional CAD provides to the designer, the computer literate architect can become a tool builder. Inventor of the parametric software, Generative Components, Robert Aish states that architect as a tool builder can define his own generative components and define their transformational behavior (Aish, 2003), enabling maximum benefit from computers.

From the Renaissance Era when architects clearly distanced themselves from the builders, domain of the lead architect has been redistributed to various professions due to the increasing complexity of buildings, and the fragmentation of building design into more disciplines. Tooling allows connections among research, design, depiction and making that have not existed since specialization began during the Renaissance (Kieran & Timberlake, 2003). By integrating these aspects through the agency of tooling, architect can once again become a figure of authority, transcending the role attributed.

Tools may take various roles in the design process. From a simple surface population to an intricate form finding experiment; cost optimizing to programming an interactive spatial environment, variety of the role a tool can have is only limited by designer’s choice and capacity. They are utilized in different stages of the design process, directly affecting the level of interactivity between the designer and design, and affecting the level of mass customization in the design process in return.

### 4.1.3 Classification

Rivka Oxman proposes a conceptual framework for structuring series of models of digital design methodology that has emerged in the last decade, helping to identify the complex relations and map different directions in the newly formed paradigm. As the new grammar introduced can even confuse the most experienced, it is essential to provide a solid framework to build upon.

Oxman places the designer in the center of all activities and analyzes the four design sub-processes: problem/situation input for formulation, synthesis/generation, representation and evaluation. Thus, it is possible to compare the degree of individual control over design, an aspect that has become characteristic of complex and integrated design systems (Oxman, 2006). A further analysis of the properties of design process based on implicit and explicit values as well as the analysis of the relationship between the designer and design sub-processes in terms of informative or interactive links are integrated to the framework for further classification of different digital design methodologies. Following table illustrates various digital models of design.

The framework suggests there are five classes of digital design models:

| | |
|---|---|
| *CAD models* | traditional CAD, generation evaluation (BIM) |
| *Formation models* | formation (topological, associative, dynamic) |
| *Generative models* | generative (grammatical transformative, evolutionary) |
| *Performance models* | performance based formation, performance based generation |
| *Integrated compound models* | futuristic holistic approach |

As a demonstration of the framework, a paper–based model can be depicted as designer implicitly integrating performative requirements, generative and evaluative procedures while interacting directly with the formal representation (Oxman, 2006).

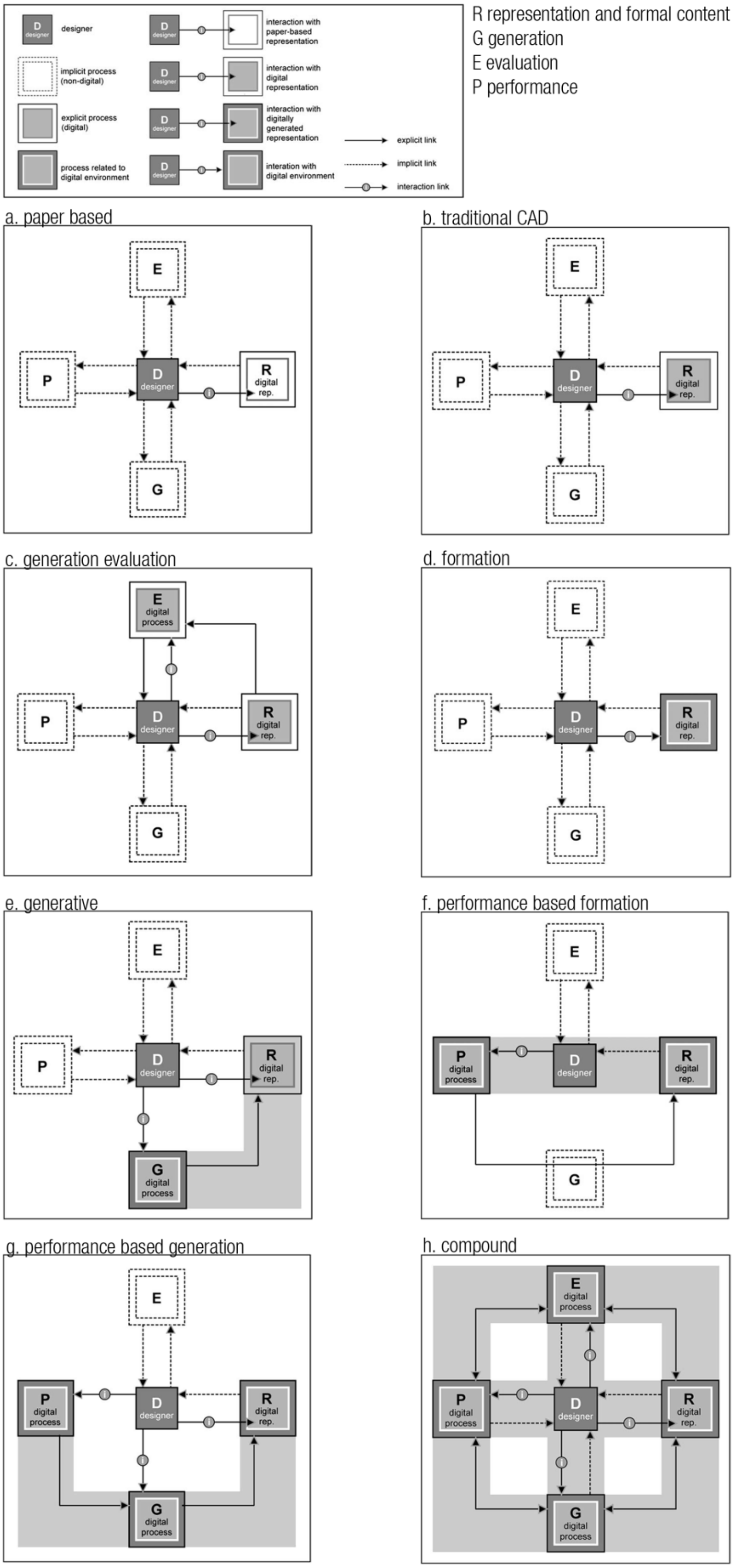


**Figure 4.2 :** Digital models of design illustrated (Oxman, 2006)

Conventional CAD systems were discussed previously, and were proven not to be digital design. As representation is transferred from manual to digital, and there are no other changes in rest of the sub-processes, it cannot be considered so.

With the automation of integrated analysis and synthesis through processing on geometrical models, generation-evaluation CAD model was introduced. These are described as predictive models as opposed to descriptive models, usually associated with cost estimation, structural behaviors and environmental performance. Digital evaluation and representation allowed collaboration between design teams, such as the architects and structural engineers. As models became predictive, they have become explicit. Interaction of the designer and design remains traditional in most ways. Designer interacts with the data structure of the representation as input to evaluative procedure that are conventionally analyzed, creating a feedback loop of interpretation through the designer who generates appropriate modifications in the representational model (Oxman, 2006).

Descriptive modeling function increasingly became well integrated with material logic and manufacturing processes to enable "dual-directional" digital processes. Although it may seem very similar to conventional CAD models, formation models characteristically exploit emergent systems; digital techniques for generating geometries are the basis for this model. The designer should demand more than the tools offered to him in the conventional CAD system, and should employ techniques such as scripting to interact with and operate in a generative environment. Designer is placed directly in the digital environment, rather than the physical environment or the digital representation of the physical environment. In addition to emergent processes, non-deterministic techniques may appear.  Designer holds a higher level of digital interaction and control over the model. However, it should be noted that the emphasis is on the formal/geometrical qualities of the design. Formational digital design may branch out to topological, associative, and dynamic formation models (Oxman, 2006). *Topological design* deals with exploitation of non-Euclidean geometry. *Associative design* is based on the principles of parametric design, whereas *dynamic design* is based on animation and morphing of the environment in a dynamic continuum.

In contrast to CAD, digital formation models provide enhanced control of variant formal generation for the geometric structure. Yet, the formal qualities of geometry are assigned directly by the architect. If the formal generation process were under provision by computational mechanisms, it would be classified as a generative design model. In this case, designer interacts with the generative mechanism that deals with the emergence of the geometry. Interaction has a major role in this digital design method. An interactive module that provides control and choice for the designer is a necessity to employ generative design models. Oxman further divides the generative design method into two: grammatical transformative design models and evolutionary design models (Oxman, 2006). First of these mechanisms is based upon formal compositional rules, while the second one employs genetic algorithms. John Holland was the founder of the genetic algorithms; however, his algorithms did not include interactivity. In genetic algorithms, populations of alternative solutions are the most important aspect, and these are gathered by defining a genetic code for a family of objects. By defining reproduction rules, variations are achieved. As the rules are altered, so are the variations.

Performance model is the process of formation driven by a desired performance. Performance models are driven by digital technologies that support form finding through design performance in an iterative process. It is the cumulative result of all design systems hitherto. Design is generated by simulating its performance. There are two possible performance models: performance-based formation and performance-based generation models of design.

The last digital method, compound models represent a future paradigm. It is based on the integration of all sub-processes of design into digital design media. Aim is to provide a full-scale interaction with any of the sub-processes throughout the design phase. It is an integrated network of enabling media.

Level of interaction between the architect and the digital design method indicates the level of mass customization in the design process. As the architect utilizes the raw power of computation as a tool, he has more control over the design than ever possible. Yet, some architects still have doubts about utilizing these powerful digital design methods in architecture.

### 4.1.4 Hesitations

> *To those uninitiated, any sufficiently advanced technology is indistinguishable from magic (Arthur C. Clarke)*

Some architects have been increasingly alarmed with possible loss of control over their own designs with the emergence and advance of CAD programs, high-end computer graphics, and modeling systems in the last five decades. For them, nature of computers remained powerful yet complicated, even mysterious. Because of the stigma and fear of releasing control of the design process to software, few architects have attempted to use the computer as a schematic, organizing and generative medium for design (Lynn, 1999). Architects had mixed feelings over the CAD, and positioned themselves within a wide spectrum of speculations. They ranged from complete rejection of any kind of digital tools, elitism of manual tools and demonizing the use of new systems to the complete antithesis, that of adoration, and worship.

Architects belonging to the first group reject digital design and claim computers hinder the architect's imagination. They believe it is just another method of marketing. As they even reject the use of BIM, it is impossible to expect them to embrace, yet alone understand different methods of digital design. They would try to scorn over the other group as being computer-savvy geeks (Willis & Woodward, 2010). Not being familiar to working with parameters and apparently disregarding the possibility of using simulations, Willis and Woodward state that parametric modeling can model only quantitative aspects of design, and as parametric design is employed, design loses its qualitative aspects and intuitiveness. They seem to conceive all digital methods only as one, and label it as blob-making process. Apparently, architects of the first group have fell short of the paradigm shift brought by the Third Wave.

Of course, some issues they point out are possible dangers in architectural design. Quoting Sulan Kolatan "It seems to me that we are in danger of falling into some of the same holes that the 1960s generation fell into. One of them is perhaps an extreme reliance on technology. We ought to be careful about trusting a new technology to create perfect solutions on its own" (Willis & Woodward, 2010).

Tooling without thoroughly designing the process itself may cause an influx of cheap imitations, and furthermore it may evolve into a dictating style. If the parameters are taken out of their contexts, the design loses its qualitative values, rendering the whole process worthless. Thus, it is never enough to underline the fact that computers are nothing more than tools that implement designer's decisions even when working with algorithms. Designer needs to be in control of the design, and algorithms, at all times.

## 4.2 Fabrication Phase

> *Machines will lead to a new order both of work and of leisure* (Corbusier, 1931)

Although Corbusier was referring to a lifestyle organized in accordance to the machines, re-interpreted, Corbusier was indeed right about his view on technological development. Machines *did* lead to a new order of work and of leisure. Humankind mastered the production methods, surpassing the necessity to adapt a lifestyle around them. Instead of confining to the standards of machines, our lifestyles dictated machines to adapt our non-standards.

From the beginning, architectural practice has been based in craft and in construction. Industries similar to architecture in terms of producing unique large-scale projects, i.e. shipping industry, have moved away from being craft-based and have been extensively using parametric design in coordination with CAM systems for decades under the auspices of process engineers. The process engineer takes the leading role and thrives on the fundamentally chaotic nature of most forms of complex design and production (Kieran & Timberlake, 2003). Process engineer acts as a mediator between the material scientist who tends to be visionary and the product engineer who aims to maximize profit, to optimize the outcome. A role similar to that of the process engineer is missing in the relation between the architect/consultant and the contractor, resulting in a poor communication between the parties. According to Stephen Kieran and James Timberlake, architects can fill this gap by extending their territory through excessive tooling. As long as they prove the COMPUTABILITY=CONSTRUCTABILITY equation, they can advocate for their designs, optimizing the scale between visionary and feasibility in the meantime.

Although architecture as a design practice has always been craft based, in terms of building components, architecture (read: building production) has gone through standardization effects of the Industrial Revolution. Just in eight years between 1921 and 1929, eighty-four product classes, some of which were building elements, showed a reduction in variety at times amounting to 98 percent of its previous level such as reduction of bath tubs to five-foot only (Lampel & Mintzberg, 1996). Timber, brick, stone, and all material sizes were standardized. While this standardization has rendered architect and builder's job a lot easier, it has also constrained them to think inside the limitations. As the world moves away from strict standardization of products, it is possible to see a variety of modularity schemes or mass customization methods adapted for every building element. Instead of looking at a building block and analyzing each entity, it is more appropriate to study the general enabling technology behind them.

Emergence of CAM and CAD were briefly introduced. Various digital design methods were classified according to their relations in generation, evaluation and representation. To open-up the subject and base it on a cumulative historical paradigm, standardization and regularization starts with the discovery of calendars and specification of time (Moe, 2010). In architecture, Leon Battista Alberti's discovery and subsequent derivation of the laws of perspective, Claude Perrault's quantification of the classical orders, Jean-Nicolas-Louis Durand's utilitarian utopia of grids, and Le Corbusier's regulating Modulor scale are each notable applications of numerical control that prepare digital fabrication techniques in architecture (Moe, 2010). Further discoveries of decimals, logarithms, slide rules, calculator and difference engine during the Age of Enlightenment all contributed to the process.

Punch-card numerical control developed under auspices of the US Army Ordnance program paved way to the electronic numerical control servo-system developed by MIT, the basis for contemporary CAD and CAM. Foundation of these system required immense federal funds. CAD arrived late to architecture, but CAM arrived even later as architecture lacks most often the economies of scale, massive capital, and government subsidies that optimize these technologies in adjacent disciplines (Moe, 2010).

Existing CAM methods were not designed for architecture in mind, thus these digital fabrication methods can only be employed for construction of specific building elements, rather than the building itself. Although there are some experimental digital fabrication methods for realization of constructions that are in development process, available digital fabrication methods will be considered for the classification. Available digital fabrication methods employed in building component scale branch into four categories (Kolarevic & Malkawi, 2005); two-dimensional fabrication, subtractive fabrication, additive fabrication and formative fabrication.

*Two-dimensional fabrication* refers to CNC cutting, the most commonly used fabrication technique, as it is the most economically viable. Based on a two-axis motion, cutting technologies such as plasma-arc, laser-beam and water-jet are utilized for creating pieces out of sheet materials. Plate materials, such as planar or unrolled façade covers are often produced via two-axis CNC cutters.

*Subtractive fabrication* refers to the removal of a designated volume from solid mass using electrical, chemical or mechanical (multi-axis milling) methods. Before it was redesigned with a metal skin, Frank Gehry's project for the Walt Disney Concert Hall in Los Angeles represented the first comprehensive use of CAD/CAM to produce architectural stonework through subtractive fabrication methods (Kolarevic & Malkawi, 2005). For the initial full-scale model, stone panels were CNC milled in Italy and shipped to Los Angeles. Subtractive fabrication has advantages over two-dimensional fabrication in terms of geometry generation. As CNC machines are able to employ more axes in the process of fabrication, much more intricate geometries such as double-curved surfaces can be obtained. Aside from directly generating double-curved surfaces, subtractive formation techniques can be used for producing formworks off-site and on-site, increasing the variety of materials accessible for construction. As shown in the figure, concrete walls in Gehry's Zolihof Towers in Düsseldorf were generated with this method. CNC produces the mold for the double-curved panels by milling the styrofoam. Supporting steel structure is laid in the mold and concrete is poured. The piece is barcoded and later assembled on site. Instead of concrete, other materials such as glass or resin can be poured (without additional steel support) to produce double-curved panels as well.

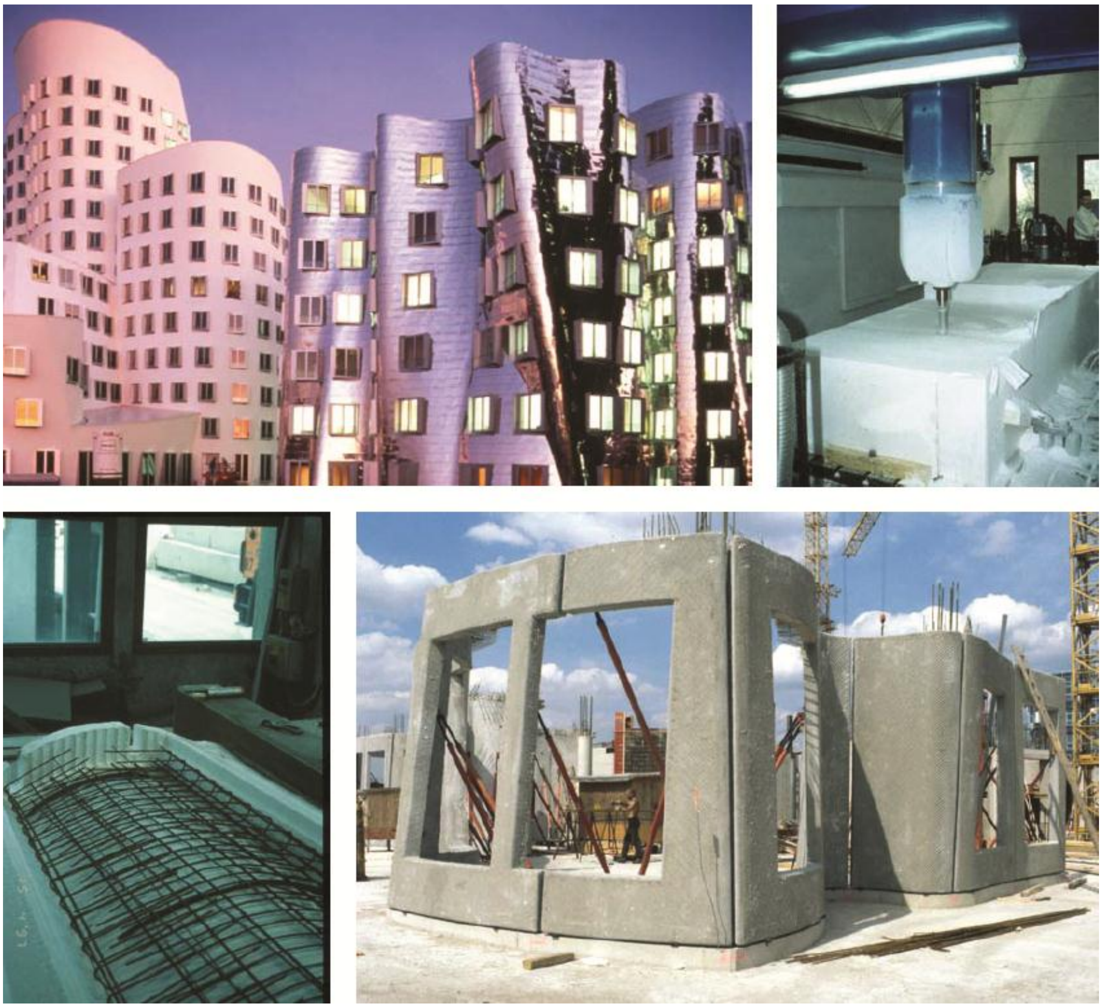

**Figure 4.3 :** Formwork generation for the double-curved concrete panels

Both two-dimensional and subtractive fabrication techniques are not considered sustainable methods as the production systems are based on removing materials, producing excessive materials that are relatively not recyclable in the process.

*Additive fabrication* refers to incremental forming by adding materials in layers. All additive fabrications share the same principle, division of the digital model into a series of planar sections. These sections are later generated in a layer-by-layer fashion. First introduced in 1988 by *3D Systems* as stereolithography (SLA), the three-dimensional printer uses laser curing of resin, built one layer at a time, to create models. SLA devices have developed to include plaster, plastics, rubber and even powdered metal.

Additive fabrication methods are rarely used in building design as the objects produced are limited in size, the equipment is costly and the production time per unit is considerably high. However, it is a tempting method if incorporated with mass-standardization techniques, i.e. to form patterns of repetitive complex-geometries for casting. They are considered highly sustainable methods, as there are no excessive materials produced.

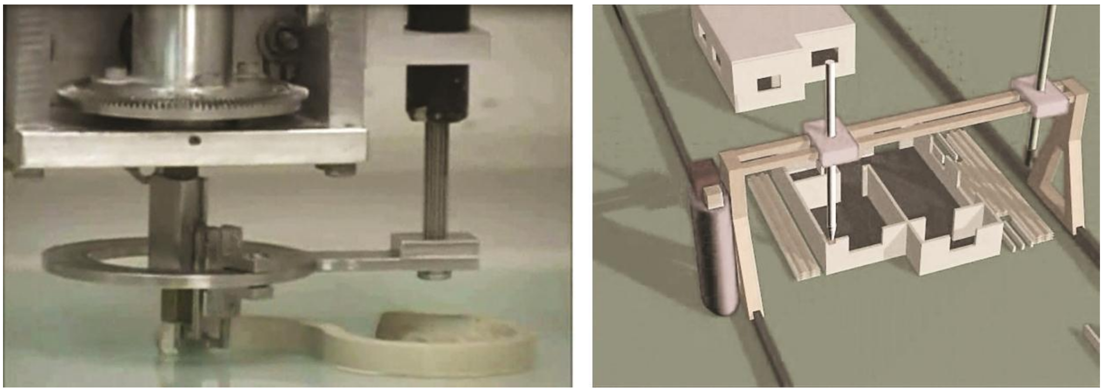

**Figure 4.4 :** Contour Crafting prototype and simulation

An experimental manufacturing process specifically designed for building construction under development by Behrokh Khoshnevis of University of Southern California's Information Sciences Institute, *Contour Crafting* is a hybrid of multi-axis robotic CNC system with additive formation techniques (Kolarevic & Malkawi, 2005). The system produces walls using sprayed concrete guided by a computer-controlled trowel. As the design and fabrication is computer-controlled, another robotic arm is used to precisely add other building elements such as plumbing, heaters, sensors and other infrastructural elements.

Last fabrication method, *formative fabrication*, is based on application of mechanical forces or heat to reshape or deform the material into the desired shape. Plane curves for double-curved façades, rods or tubes of steel or wood can be fabricated this way. This method is relatively more sustainable than subtractive fabrication, but not as sustainable as additive fabrication.

In all methods, as components are digitally fabricated, they are barcoded for identification for precise assembly either as manually with the help of guiding lasers or by robotic devices.

### 4.3 Interactive Architecture

Dwellers have always been customizers. From the time they lived in caves and tree barks to the time they lived in high-rise condominiums and converted lofts, dwellers strive to change their immediate environment. Aside from providing a certain level of comfort, as discussed previously, this act of personalization can be attributed to the persona-building process of the individual. Dwellers, mostly, are in a unilateral communication with their immediate environment through this persona-building process. They acquire items for themselves, organize the space they occupy with these items, re-organize, and replace the items if necessary. Immediate environment remained stable, as there were no extra performances expected from them.

Recently, expectations from buildings have risen with the advance of technology as architects and engineers developed building components that could react to certain stimulators. Buildings, as entity, are expected to perform better under environmental conditions, adapt to the changing conditions in real time if necessary. They are expected to obey what the users command them to. With the rise of the "smart building", the type of communication between user and the building has shifted from unilateral to bilateral. There is an action asserted to the receiver, and the receiver reacts according to the action. Although this is an improvement from the conventional unilateral relation, it is still a limited relation. Conversation between the actor and the receiver is limited to one cycle, or repetitive cycles of pre-determined answers. Reactions of the receiving party are predictable, even in the case of having a database of a wide array of possible reactions. Certain actions cause certain reactions.

Both relations are relatively naïve when we consider our relations in the virtual environment. There is a great oxymoron. While we ridicule computer games of two-three years old because of their lack of artificial intelligence since the bot playing against us was too easy to defeat; we name buildings that merely open their shutters at the specified angle on user command "smart". Buildings, considering their current capacities and areas of use, are not smart. They are not even close.

Enter *interactivity*. “Interactive” is one of the words that is mistaken the most. Interactive architecture is mistaken as, but is neither, a responsive nor an adaptive system. Interactive systems are more than that; interactivity is based on the concept of bi-directional communication requiring two active parties (Oosterhuis, 2010). For a system to be interactive, two parties should act (input), think (process) and react (output) in turns. Communication between two or more parties should be an on-going activity, not restricted to a moment. Indeed, interactivity is a game played between two parties.

Why do people value the playful aspect of interactivity?

Importance of the notion of game was discussed as early as 1938 by Johan Huizinga in his book *Homo Ludens*. Latin for “playing man”, Huizinga discusses that possibly play is the primary formative element in cultures and investigates the play element of culture. According to Huizinga, play is not part of ordinary life, both in locality and duration, meaning that it takes place in a specifically designated field, with a certain timespan and with a defined set of rules (Huizinga, 2008). Play suspends life and shifts it to another parallel world. For Huizinga architecture, an infrastructure of limits and possibilities, serves as the basis for the play. However, Huizinga does not hint anything about architecture’s active involvement in play.

Constant Nieuwenhuys built upon the idea of play in his life-long work New Babylon. The era that Constant started designing New Babylon should be noted carefully in order to understand the derivative emotions. Emergence of New Babylon corresponds to the post World War II era, era of the baby boomers. Social rights were severely restricted to the courtesy of white males. In such a dull environment, he envisioned New Babylon as another city for another way of living, as a sort of strategy for survival in hard times. Attributing directly to Huizinga’s notion of play, Constant stated that if the distinctive feature of the avant-garde was its critical struggle against the existing culture, then, in the contemporary situation, artists were to pave the way for an emergent culture of play (Heynen, 1996).

Homo Ludens were the occupants of New Babylon. Constant gave the priority to the public space, which acted as the arena for play. He believed that culture is not possible without quality public space and play is a necessity in the public domain. Public domain is an urban atmosphere that involves freedom, complexity and limitless possibilities. Everyone occupies the public space; private space is only available to those who are ill or unable to participate in play. New Babylon is a supra-structure consisting of various sectors that extends over historic European cities, yet there are no authoritarian designers dictating the scheme. Constant declared, “The real designers of New Babylon will be the Babylonians themselves” (Heynen, 1996). In a bottom-up design fashion, settlers of this techno-utopia modify the space through the direct interactions with all the building elements near them. Constant’s New Babylon adds new elements to Huizinga’s notion of play. Whereas architecture serves as an infrastructure, a static playground for the play element, New Babylon’s supra-structure promotes play through its own structure. The playground has become flexible, mobile, and interactive.

Manfredo Tafuri also supports pursuing the element of “game”, arguing that the public must be convinced that the chaos in cities contains an unexplored richness, unlimited utilizable possibilities, and qualities (Tafuri, 1976). He summarizes his vision of urban ideology as architectural and supertechnological utopianism where games are methods to involving the public in imagination-driven lifestyles.

Kas Oosterhuis tries to take the public play element and incorporate it to building scale, while establishing an interactive connection with its initial designer and its users in real time. During his inaugural speech as dean to the faculty of architecture in Delft University of Technology, he proclaims, “E-motive architecture produces the hyperbody.[28] A hyperbody is a programmable building body that changes its shape and content in real time” (Oosterhuis, 2002). In further detail, hyperbody is to building, what hypertext is to written information, thus the hyperbody building is the vehicle for processing information. The hyperbody building becomes programmable, through the better utilization of adaptive/reactive systems. Hyperbody can be programmed to become dynamic, and change shape even in real time. In his, own words “Architecture becomes a game and the users the players” (Oosterhuis, 2002).

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[28] Later on, Hyperbody becomes the name of the chair he has founded in TU Delft.

Interactivity can take place in two forms in buildings, either as relations between built components, or as relations between people and the built components, all in real time. By now, we are familiar with the interactivity between people and the built components. The interactivity between built components themselves relies on identification of each component. Since they are produced by digital fabrication methods, they already possess a barcode that refers to every single component. These components must act as a swarm to become fully interactive, meaning every component may have its own behavior yet under one body, they must move as an entity.

**Figure 4.5 :** ADA by ETH Zurich

ADA, developed by ETH Zurich is a decade old example showing the two types of interactivities employed. Named after Lady Ada Lovelace, a pioneer of computer science, for display in the Swiss national Expo 2002, ADA is based on research on neuroinformatics. Through her senses, i.e. vision, audition, and touch, ADA is an artificial organism that can interact and communicate with her visitors. She senses her visitors through the sensors placed around the room, locate and identify her visitors, balance visitor density and flow according to the input from the sensors, track and guide "interesting" visitors, group selected visitors in space for promoting further interactivity between the player, and play games such as real-time physical group pong with visitors (Eng, 2001). She is the embodiment of playground in the digital age. She transcends being an infrastructural architectural element serving for people, a regular playground, by becoming an active party in the event of play encouraging people to play.

It is important to note that all experimental contemporary interactive spaces strictly remain in public domain, as none has dared to cross to a more private domain, such as housing. As the notion of interactivity roots to the element of play, which takes place only in public domain according to Huizinga, interactive installations have remained public. Even though Oosterhuis claims he wants his buildings and eventually all buildings to be totally unpredictable and surprising (Oosterhuis, 2002), it is challenging to expect everyone to accept interactivity in private domain. After all, even New Babylon was established as a utopia with the assumption of abolishment of private dwelling, making every person a wondering nomad in the interactive super-structure. Yet, Constant spent the last years of New Babylon depicting how it was possible to "dwell" in New Babylon (Heynen, 1996) since everyone's best interest could not be possible with the enabling superstructure, introducing dystopian architecture in the meantime.

Unilateral relation with our immediate environment only enables customization. Mass customization of architecture during the usage phase of design is only possible through a bilateral relation between the user and the surrounding, of which an interactive relation compared to a reactive relation offers limitless possibilities, greatly enhancing the experience the user gets.

### 4.4 Case Studies

By comparing different practices and their methods of utilizing computers as tools, it is easier to grasp different digital design and fabrication methods employed in contemporary designs. For the untrained eye, the contemporary architecture firms may be producing similar architectures, yet they vary greatly in every step of design and fabrication.

Digital design and fabrication methods' reflections on the end-users will be compared as well, as it is one of the indications for active customer involvement in the design process. Methods employed are matched with various mass customization classifications (i.e. classification of customization, level of modularity/interactivity, tooling classification, etc.) mentioned earlier. Comparably popular names have been preferred as the reader is already introduced to them and their works via architectural media and does not need re-introduction.

Following are the practices whose utilization of digital design and fabrication methods will be discussed, along with their brief introduction:

| | |
|---|---|
| *Zaha Hadid Architects (ZHA)* | Starchitect |
| *Gehry and Partners* | the Bilbao Effect |
| *Oosterhuis and Lénard (ONL)* | Hyperbody |

Aside these practices, Marcos Novak's works in cyberspace, which transcends architecture and borderlines a hybrid of design and art will be discussed in *... and beyond*.

### 4.4.1 ZHA

While mentioning the work of ZHA, many oversee the effects of her partner, Patrik Schumacher. Co-founder of Architectural Association Design Research Lab (AADRL) with Brett Steele, he is a prominent academic figure that has taught in many prestigious architecture faculties in Europe. He believes in the innovativeness of the architect, stating that architect is a radical innovator in the field of spatial organization and only the small and particular segment of avant-garde production defines the essential character of the discipline (Schumacher, 2002). His opinion on the architect's role hints the reason why he chooses to work with Zaha.

Schumacher also gives great importance to digital design and fabrication methods. Although a little confused as stated previously, nonetheless, he is still an avid supporter of computation in architecture, he believes the contemporary methods unified under the proposed name of "Parametricism" will be the successor to Modernism in his manifesto, promoting it as the next global style (Schumacher, Parametricism - A New Global Style for Architecture and Urban Design, 2009). Since parametricism has its roots in the digital animation techniques of the '90s, he believes animation softwares can be used for architectural purposes as well.

Through his efforts, ZHA has started employing new digital tools. Effects of these tools can be traced in the series of completed projects. There is a strong difference in design language between Contemporary Arts Center in Cincinnati, the Vitra Design Museum in Weil am Rhein and the Zaragoza Bridge Pavillion or the Guangzhou Opera House.

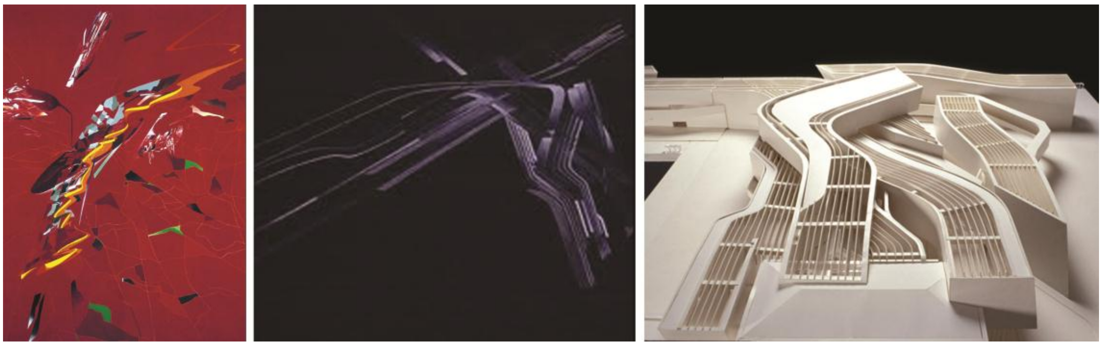

**Figure 4.6 :** paint/sketch/model

The initial design tool has stayed the same in practice. Designs are kicked-off with skecthes or paintings, eventually finding their way into the software, resulting with a physical model. The figure shows an earlier painting by Zaha, a sketch in the initial phase of the MAXXI project in Rome, and lastly the model of the completed building. Articulation of design through parametrics is limited to rather cosmetic aspects, such as the formation of the roof louvres. Design is mainly based on the napkin sketch, there is hardly anything computational about it.

Even though urban implementation of parametricism is a recent development, ZHA was able to win a series of international masterplanning competitions (Schumacher, 2009). Zaha Hadid’s entry to the invitation-only competition for the Kartal-Pendik masterplan is one of the first works of parametric design applied on an urban scale. Primary design goal was to integrate a grid into the organic fabric of the site. Thus, a script that acted similar to the wool threads of Frei Otto was written in Maya Embedded Language (MEL) to connect the roads divided due to the intervention with the minimum detour possible. Further characteristics for the urban grid, such as environmental performances were also added while transforming the blocks in 3D. Negative / positive space relation between perimeter blocks and cross towers are controlled by the global Maya model as well.

**Figure 4.7 :** Kartal-Pendik masterplan woolthread study and proposal juxtaposed

Even though urban massing studies is an area parametric design may thrive due to the richness of design inputs, the proposal for the site merely traces the simulations, as top-down sketches dictate the final product as can be seen from the juxtaposed images of the study and proposal. Simulations fail to transcend into the actual proposal phase.

Furthermore, Schumacher, un-intentionally through a small nuance of a word, admits the mis-use of parametric software. While justifying the use of the digital methods, he claims “the danger of overriding real-life richness is minimized because variety and adaptiveness are written into the very genetic make-up of parametricism” (Schumacher, 2009). He confuses parametrics, a method for mass-customization, with variety, a top-down strategy that contradicts mass-customization. Parameters are not for producing a variety of random results, but are rather to provide the optimum result. It is possible for a parametric software to lead to a variety of choices only if the parameters for the design are altered, indicating a change in design itself.

David Celento argues that the emerging technologies with implication for architecture require a generous dollop of desire in order to be realized (Celento, 2010). He agrees with Schumacher on one point, deviation from commonly accepted architectural practices is for visionaries, the innovators. Fame may be enough to generate required desire, but only if your name is already a brand. Thus, there is a high probability that starchitects will be using these new methods just as another tool of marketing, perhaps as a varification of their design. ZHA can be examplary in this aspect.

There is a clear distinction between the design and fabrication phases. ZHA uses the Digital Project by CATIA, a BIM for integrated design and engineering developed by Gehry Technologies, after the initial design decisions are taken. Fabrication phase of the design starts where the design ends, thus there are no implicit bonds between the two. It is not much different from a conventional building in terms of hierarchial status of production stages. Except for the design of some environmental elements, there are no emergent nor bottom-up design decisions. Everything is dictated top-down.A rough model generated in a modeling program is either transferred to another parametric software such as Generative Component, Rhinoceros’s Grasshopper, or through MEL scripting, generatively acquiring its building elements as seen in the example of the Zaragoza Bridge Pavilion.

**Figure 4.8 :** Zaragoza Bridge Pavilion

User interaction and customer involvement in the design process is non-existent. Designs can even be cynical. In the Venice Biennale of 2008, where the theme was Beyond Building – a theme that promoted the digital design methods as well as the aspect of play, Zaha's supposedly "interactive space/furniture" installations were the only installations with placards warning the visitor to "not touch".

Overall, ZHA design strategy fails to harvest the computational value, as the emphasis is on Zaha brand. Techniques employed are tools for improving the brand, not the design.

**Figure 4.9 :** Zaha in Venice Biennale 2008

### 4.4.2 Gehry and Partners

Frank Gehry has become synonymous with the use of non-Euclidian, curvilinear geometry combined with cutting-edge technology and extensive use of CAD/CAM in his designs. However, Gehry himself remains skeptical of computing as a tool for design, speaking with a certain degree of pride in his inability to operate a computer, suggesting that the quality of the digital image is dangerous and subversive to the designer's eye (Shelden, 2002). Thus, he chooses to work with physical paper models starting from the initial design stage.

**Figure 4.10 :** Paper models of Experience Music Project

Although paper modeling may seem like a conventional method, Gehry's paper models differ, as they are more than just volumetric experiments on site. These models are the hybrid result between the physical and digital model in a "dual-directional" process (Oxman, 2006). The paper model is a descriptive tool that contains material logic and manufacturing processes. It has the same properties with any other sheet cladding material, meaning the surface has to be developable in order to manufacture with 2D cutters. Physical model loaded with material behavior is translated into digital environment via digitizers or 3D scanners. In Gehry's hands, traditional CAD has evolved to integrate the virtual with the physical.

*Experience Music Project and Science Fiction Museum and Hall of Fame* (EMP) is a museum in Seattle, dedicated to Seattle's music scene and named after Jimi Hendrix's band. Gehry was commissioned for the design of the building. Previous figure shows the paper models of EMP with material logic. The two images above show EMP design prior to selection of cladded surfaces. Initial design was considered as deformed blocks. As the design was altered and metal sheeting materials were chosen as cladding, new physical models are built with paper and similar materials to explicitly show material qualities. Physical models are translated into digital in every step of design to provide greater flexibility. Physical models are important tools throughout various stages of the project for the architectural practice.

Gehry's designs rely on the master model methodology; an integrated repository for three-dimensional CAD based description of all aspects of construction. As it is considerably time-consuming to accommodate the non-Euclidean geometry structure of the designs in architecture oriented BIMs, which excel at Euclidean geometries, Dassault Systems's CATIA, a software primarily used in the aviation and car industries, is used as the software of choice. All design and engineering groups work on the same digital master model, ensuring a flawless integration between different parties, enabling working on the same complex system.

As engineers share the same digital model the architects use, engineers are involved early in the design process and they become responsible for their part, improving the communication between the two parties throughout the design process, which is crucial for complex designs. Since the building is digitalized as a whole entity and becomes open-source, analytical models can be generated by running simulations on the digital model. Computational Fluid Dynamics techniques can be used to model air, energy and particulate flows through spaces with complex shapes (Shelden, 2002). However, the feedbacks from these simulations do not directly affect the design, but are considered by the designer while generating the next generations of the design. Required 2D drawings can be generated by literally sectioning the 3D model, thus enabling a much easier drafting process.

Up to this point, Gehry's utilization of digital design tools is based on generation evaluation descriptive models. Design is still based directly on the designer's subjective choices amongst variations generated. Although there are computational simulations ran by the system, it is not integrated implicitly into the design process.

A Gehry project can be intimidating for the client and the contractor in terms of geometry construction and construction budget. It is not an overstatement to say that project budget control – and the reconciliation of design intent with project financial requirements – is the most important driving force behind the firm's design development decisions (Shelden, 2002). As opposed to the general opinion about Gehry's customers being budget*less*, it is indeed Gehry's ability to complete works within the given budget, by being able to project expenditures in real time thanks to the digital master model. However further optimization of the digitized physical model is required to decrease the construction costs. The non-Euclidean geometry should be optimized as much as possible for fabrication efficiencies. This means the reduction of costly double-curved surfaces and opting for rather easier and cheaper to fabricate, single-curved or flat surfaces. A high degree of rationalization is an absolute necessity for realization of these surfaces. This process cannot be achieved by using any conventional CAD or BIM tools.

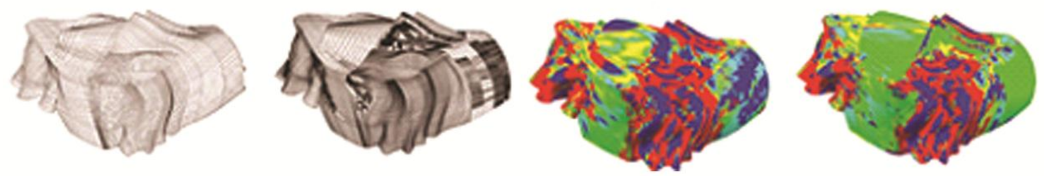

**Figure 4.11 :** Surface optimization in EMP

Gehry Technologies, a team of architects and engineers solely responsible for developing computational tools for the architectural practice, developed *Digital Project* based on CATIA to address the issue of rationalization. With the help from the parametric software, architects can solve the mathematical and geometrical relations required for the rationalization of geometries, without sacrificing the main nuances of the form. As Digital Project is a built-on for the existing software, the main digital design method gains associative design formation qualities.

**Figure 4.12 :** Fabricating a structural rib in EMP

Gehry's designs, which are celebrated for their bold forms, are actually far more groundbreaking for its use of innovative digital construction methods that are infused to the digital design methods. Fabrication strategies are set very early in the design phase, affecting all design decisions taken. One of the early structural decisions in EMP was to form different volumes by the curved I beams, built up from custom cut plate elements. A series of planar sections through the volume was generated from the parametric software, and they were rationalized for their curvatures. These curves were then flattened in 2D for CNC feed. As shown in the figure above, rib web and flanges are cut from a steel sheet with the help of plasma CNC. A custom-built CNC plate-rolling machine, a formative fabrication method, then rolls cut pieces. Rolled top and bottom flanges of the ribs are connected with the rib web and the rib is pre-fabricated in the metal shop and barcoded for assembly on site. For another digital fabrication method Gehry employs, refer to the previous example given – the fabrication of the double-curved formwork and surfaces of the Zolihof Towers in Düsseldorf.

Kiel Moe notes that modifications to Gehry's contract structure engendered the tools developed by Gehry Technologies, not the adoption of techniques and technologies (Moe, 2010). In Gehry's case, advocating for digital design and fabricating techniques is a social implementation, rather than technical. Moe also suggests that digital fabrication technologies cannot change building production without fundamental shifts in the social and market structure of design practice (Moe, 2010). It is possible to trace this to the argument based on Celento's view on validating design through brand, promoting the starchitect. Most of Gehry's designs remained on paper in the *pre-Guggenheim* period. *The Bilbao Effect* benefited him the most, as clients flocked to him for generating values for their projects through his brand. Instantly, he became an object of desire.

The architectural practice has employed mass-customization techniques in its originally intended function of a tool of marketing as well, successfully providing unique Gehry experiences for the clients. However, the buildings do not actively communicate with the end-users. In terms of level of interactivity with the end users, they stay as inanimate objects. Forms can be alluring, and they even might seem "playful", yet there no interactions between the users and the buildings in any way unless you are the façade cleaner as depicted in Ila Beka and Louise Lemoine's feature film *Gehry's Vertigo*.

**Figure 4.13 :** Still from Gehry's Vertigo

### 4.4.3 ONL

Oosterhuis summarizes his view of the architecture in the information age as “the programmable hyperbody played skillfully by its masters at the speed of light” (Oosterhuis, 2002). He is a firm believer in the role of the virtual reality in architecture. Oosterhuis states that virtual reality is more real than so-called reality, as it is hyperreal – in the sense we *know* the stuff it is made of (Oosterhuis, 2002).

Hinting to Novak’s “all that is solid melts into information”, he reasons “matter is information, architecture is information”. It is in the hyperreal environment of virtual reality ONL designs. For this purpose, Virtools is used as the tool of choice, gaming software with a user-friendly scripting language that vastly improves the computational output, also developed by Dassault Systems. As opposed to ZHA’s method of using Maya and MEL for the sole purpose of modeling intricate forms of ZHA; ONL relies on gaming software’s powerful quantitative (i.e. solar, particle-based wind and water, etc.) and qualitative (crowd displacement, behavioral, etc.) simulations.

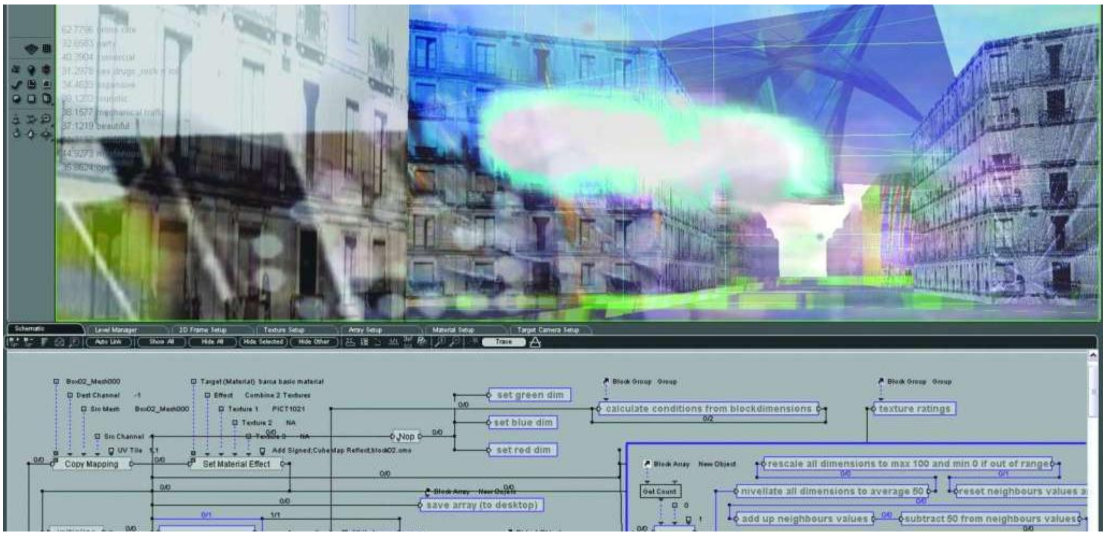


**Figure 4.14 :** Virtools interface

However, it is important to separate Oosterhuis’s academic works – those that are theorized or prototyped in cooperation with the Hyperbody in TU Delft, and his collaboration with Ole Bauman - from his practice, as they rely on different aspects of digital design methods.

**Figure 4.15 :** Trans-ports evolving into the Muscle

Kas Oosterhuis collaborated with Ole Bauman for developing an interactive space, which was introduced at the Venice Biennale 2000. The idea rooted to the relation of hypertexts to conventional texts. Driving question was simple: what if programmable, hyper-buildings that changed according to local information existed and reacted in real-time, connected to a network of others all around the world?

Trans-ports was a fully interactive pavilion which was considered to be built by using a space frame of pneumatic structural components, which enabled manipulations, while the interior was dictated by display screens which processed form and images constantly in accordance with a set of parameters programmed via gaming software (Oosterhuis, 2002). Although Trans-ports was not realized physically due to technical and economical restrictions, a prototype – Interactive Cave- with sixteen sensors hanging from the ceiling of the exhibition space in the Italian Pavilion allowed the interaction between the virtual model of Trans-ports and the users (Oosterhuis, 2002). The muscles of the virtual building reacted in accordance to the feedback from the sensors.

Notion of programmable interactive space engendered many research directions for Oosterhuis. One of these was the development of the Muscle for the Non-Standard Architecture exhibition in Centre Pompidou in 2003. A full pneumatic model of the evolved Trans-ports was built using flexible tubes that become longer or shorter depending on the air pressure pumped, which was developed by Festo[29]. Seventy-two muscles were programmed with Virtools to behave as a swarm. People could interact with Muscle in real time, triggering unpredictable reactions from the Muscle. Areas of contraction and areas of expansion made the NSA Muscle dance on the exhibition floor, the muscular body has been seen to rotate, hop and crawl (Oosterhuis, 2010)

Interactive nature of the Muscle gives a glimpse of the futuristic integrated compound digital design method, but since there is a lack of performance criteria for the installation, it is a generative design methodology with physical outputs. Through the sensors and the associated parameters, there is a constant cycle between generations and the evaluations of the design represented in physical as well as the digital. The fabrication of the product depends on standard materials with variable connections, thus the designer is a modularizer using sectional modularity.

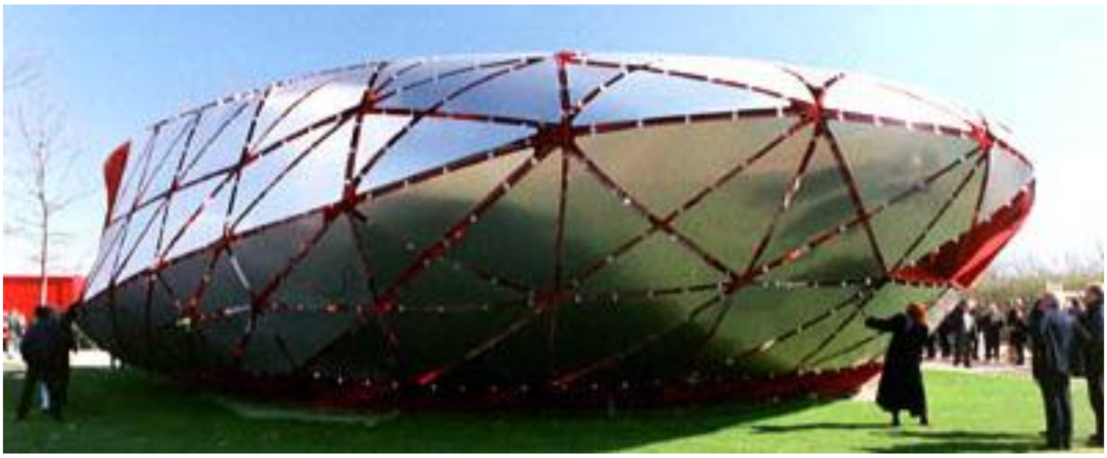

**Figure 4.16 :** Web of North-Holland Pavilion

Design of the Web of North-Holland Pavilion for the Floriade roots to a frozen moment in Trans-ports. TU Delft acquired the pavilion after the Floriade. As the pavilion was fabricated with File-to-Factory method, a term Kas Oosterhuis likes to use for mass customization during the fabrication phase using 2D cutters; the pavilion was dismantled, transported and assembled again in Delft. In its afterlife,

[29] The partnership with Festo AG developed into cooperation on educational research projects such as interactive entrance, interactive wall, and many others.

enriched with sensors to provide a reactive learning environment for the Hyperbody group, nicknamed as the ProtoSpace. Currently, it sits idle after the fire destroyed the faculty of architecture in Delft. It seems like it is part of a science fiction scene, standing like a crashed spaceship amidst the rumbles of the destroyed building[30].

**Figure 4.17 :** Hessing Cockpit, Utrecht

However, it was an infrastructural project commission that has put Kas Oosterhuis and ONL on the contemporary architectural scene. Hessing Cockpit in the Acoustic Barrier on A2 Highway between Amsterdam and Maastricht stands out as a masterpiece of contemporary architecture that utilizes digital design and fabrication methods: an infrastructural system that acts as an acoustic barrier then transforms as it progresses to become a real building (Oosterhuis, 2010). It also resembles the typical design flow of the commercial works of ONL.

In the original brief, the acoustic barrier and a commercial building were distinct entities, but ONL merged them as the project was conceived conceptually as one unified entity. Based upon the input curves defined by the designer, first parametric model integrates the same detail to surface subdivisions, while the second parametric model describes the steel construction and glass elements. All necessary fabrication details are gathered by establishing a point cloud of thousands of reference points, each of them representing a position in space allowing of scripting description of all constituent building components with high precision (Oosterhuis, 2010).

[30] Although the site was cleared, it still sits idle on the leveled ground resembling a sci-fi scene.

The data driven from the architectural design script had such high precision that the manufacturer could use it directly for CNC production of all components; steel, glass, and rubber. All parts are barcoded and assembled on site precisely.

Generation of the surface elements are designed through associative parametric methods, considering different parameters in each design.

The design and fabrication processes are interwoven, creating a direct link, or as Kas would like to call it establishing a File-to-Factory (F2F) method. Despite his emphasis on bottom-up systems and swarming systems, the designer constructs guiding NURBS curves and imposes a top-down approach. Oosterhuis refers to this part of the design as the “e-motive”, stating that an architect can intuitively design with the help of mass-customized systems, causing a partial oxymoron between his academic works and his works in ONL. However, the difference in the approach can be justified as the co-director of ONL is Ilona Lénárd, a visual artist with a prominent sculptor background, thus bringing a different approach to the design strategy.

During the design phase of the Cockpit Oosterhuis declares, “Mies is too Much!” (Oosterhuis, 2010), building the whole body based on a unique, yet single repetitive detail. There is a partial rationalization of the design, but the architect superimposes the rationalization rather than generating it iteratively considering material aspects, as opposed to Gehry’s method of rationalization of surfaces. This leads to two different production strategies. As the detail applied everywhere is the same, a complex detail model can be manufactured by an additive fabrication technique, to be later used as the mold and then mass standardized, since a high volume of a standard element is needed. However, the parts these details connect are all unique parts, but since they are all triangulated, they are planar and can be cut via a CNC cutter. This is an effective choice for cutting costs in non-standard buildings.

The element of play, an element he avidly promotes in his installations is missing in the commercial buildings, rendering his buildings frozen in time like sculptures.

#### 4.4.4 … and beyond

*All that is solid melts into information* (Marcos Novak)

Architecture has been earthbound, even though its aspirations have not (Novak, 1991). Current technology and its economic feasibility are limited for the implementation of full-scale, interactive mass customization systems in architecture. Thus, architectural practices commissioned for the realization of a building can only use mass customization methods to an extent. To exploit the traits of mass customization further, free from technologic limitations and budget restrictions, architect should turn to the virtual domain for the realization of a full-fledged mass-customized architecture. In order to investigate the architecture and mass customization in virtual space, a brief apprehension of existence is essential.

Any matter can be defined by three values: mass, energy and information. Hitherto, first two values had accounted more compared to the third. Linked to gravity and materiality, mass and energy of a matter were used primarily for defining the matter as they were conceived to be durable aspects. However, in a world where everything is subsequent to a rapid change, information is of utmost importance and thus much more valued as information tends to be fugitive, evolving through time and keeping in pace with the changes. Information counts more than mass and energy, as it takes the place of the thing itself (Ruby, 1998). In the sense of Gustave Flaubert's phrase, *L'image vous plus que la chose dont elle est image*.[31]

As the emphasis on information grows comparatively more than mass and energy, the physical attributes of the object loses its importance in comparison to its prior state. In a sense, it becomes possible to conceive matter that is never perceivable with physical eyes. We draw nearer to Plato's εἶδος, which constitute the essence of the matter – the raw ideal. At this point, it is possible to speak of a state of disappearance of the physical matter as we know.

[31] *Fr:* The image is more important than the thing of which it is an image

Disappearance not only affects architecture, but any kind of materiality: the earth (deterritorialization), the body (disembodiment) and architecture (deconstruction – in the literal sense of the word, not the architectural style) (Ruby, 1998). Matter vanishes in favor of information. Disappearance should not be mistaken with being eliminated; architecture will continue to exist, but in the state of disappearance.

Disappearance in this context is a *Négatité*, an activity Jean-Paul Sartre refers as something which while not obviously involving a negative judgment nevertheless contains negativity as an integral part of their structure, containing *Nothingness* at the heart of *Being* as its nature. Disappearance, like other *Négatité*s, is a transcendent reality indicating an essential relation of human reality to the world (Sartre, 1943). Disappearance renders the dualism of being and appearance obsolete. It is a nihilating[32] process where appearance comes to reveal the essence. In Sartre's words;

> *"... essence, as the principle of the series is definitely only the concatenation of appearances; that is, itself an appearance*
>
> *... The reality of a cup is that it is there and that it is not me.*
>
> *We shall interpret this by saying that the series of its appearances is bound by a principle which does not depend on my whim"* (Sartre, 1943).[33]

Cyberspace offers a world nihilated, an absolute form – *Nothingness*, where novel architecture – *Being*, can be shaped. While it is possible to create a simulation of our existing world, it is also possible to create new worlds as architecture shifts to the structure of relationships, connections and associations that are webbed over and around the simple world of appearances and accommodations of commonplace functions (Novak, 1991). Architecture is nested within architecture; cyberspace becomes the architecture, as well as containing architecture, limited only within the constraints of its designer.

[32] *Néantir* (nihilate), a word coined by Sartre. Consciousness exists as consciousness by making a nothingness arise between it and the object of which it is consciousness. Thus nihilation is that by which consciousness exists
[33] Readers are suggested to read Sartre's *Being and Nothingness*, Part 1-The Problem of Nothingness for a better understanding of phenomenological approach to existence

> *By changing space, by leaving the space of one's usual sensibilities, one enters into communication with a space that is psychically innovating. For we do not change place, we change our nature* (Bachelard, 1966).

Even though Gaston Bachelard refers psychologically transformative potential of physical extreme environments such as the desert, the plains and the deep sea, the hyperreal behavior of the cyberspace suits his view of de-automization of perceptual sensibilities for perceptual expansion the best. Thus, some pioneers have turned to cyberspace for the realization of their architecture, an architecture where new experiences can be achieved by re-interpreting the existing stimuli or through creating stimuli never experienced before.

Amongst the important figures of this new generation of architects such as Lynn, Oosterhuis, Spuybroek and Rashid, Marcos Novak stands out from the rest as a non-practicing architect who focuses on the subject with an architecture and media background.

He conceives cyberspace as liquid, an architecture that is more than kinetic/robotic/fixed architecture; it is a being that breathes, pulses, and leaps from one form to another  (Novak, 1991). Architecture should provide the connections the user demands, in perpetual fluctuations. In Sartre's terms, the principle of the series gains importance as any particular appearance of the architecture loses its significance. The architect has to design the principles in design, not the objects as they have to be emergent. Liquid architecture in cyberspace is a dematerialized architecture.

For Novak, the new paradigm in architecture shows itself in two faces. Liquid architecture within cyberspace constitutes the first, whereas the second is an invisible electronic double superimposed on our material world, a digital representation of set of connections architecture bears. Novak names the new architecture *transArchitecture*, an architecture beyond architecture, mediating the transition between actual and virtual in the manner that conventional architecture mediated between knowledge and experience (Novak, 2003). Novak summarizes this duality as follows.

> *…we conceive algorithmically (morphogenesis); we model numerically (rapid prototyping); we build robotically (new tectonics); we inhabit interactively (intelligent space); we telecommunicate instantly (pantopicon); we are informed immersively (liquid architectures); we socialize nonlocally (nonlocal public domain); we evert virtuality (transarchitectures)* (Spiller, 2000)

As the way people perceive, design, fabricate, live, and communicate transcends from the physical into the digital, architecture has to stand at a mediating point to provide access to both sides. Living in the cyberspace is not a utopia. For Novak, architecture has become transmissible and is already in cyberspace. With the advancing technology, the necessity of physical presence decreases by day. We are present in social networks at any time of the day at any place covered by our mobiles; institutions have dematerialized as well as our identities; and we are becoming cyborgs[34]. We are transcending beyond our physical reality and its restrictions.

It is not a coincidence that Novak prefers to name this architecture *transArchitecture.* The notion of transcendence is mentioned often throughout his projects and writing, as Novak sees the potential in the virtual space for the creation of the new architecture. Virtual is not the nihilated form of the physical, on the contrary the act of Transcendence, which is "the project of self beyond", is far from being able to establish nothingness; it is nothingness which is at the very heart of transcendence and which conditions it (Sartre, 1943). Virtual space is an absolute starting point.

Thus, cyberspace and the virtual domain provide the ultimate ground for mass customization as it enables a deep immersion in the digital environment where the architect can set his rules from the very first step. After establishing a series of connections and associations, the users can generate their own personalized environments. These connections can be considered as the modules in mass customization systems. Furthermore, these module-associations help define the space explicitly, becoming more than just a means of economic production method. User interaction is limitless. Cyberspace is the *Soft-Babylon*.

[34]Body enhancements such as limb prosthesis or even contact lenses can be considered cyborg-like. On the other hand, STELARC (Stelios Arcadios)'s works on the integration of mechanical and organic enhancements to his body may qualify him as the first cyborg.

**Figure 4.18 :** Novak's Turbulent Topologies

Pictured above, Novak's interactive installation Turbulent Topologies which was open to public and on display in 2008 in Istanbul shows his vision of space in action. A cube installed hovering inside the gallery space tracks the user's movements via the motion and proximity sensors. Users' movements are projected onto the virtual space and their trajectories are stored and reflected onto the display on the wall. Users also use a handheld tripod tracking device for the generation of spaces, and are informed in audio whenever the tracking device hits an existent representational space in the digital informational model represented through the hollow cube. After the course of a week, all the gathered information is put together mapping the space in 4D. Some of the frames are picked and 3D printed using SLA to represent the digital model in the physical world.

Novak's method is an interactive compound digital design method. Architect sets the initial rules for the space configuration and leaves users the freedom to generate their space. AS the space is generated in the virtual and only a frozen time in the informative 4D model is materialized, this method suits its purpose. However, the application of it in building design is challenging in terms of technology and feasibility.

# 5. CONCLUSION

Change in production systems have caused paradigm shifts on the communities of their time and have affected architecture in return. In addition, Renaissance has played an essential role shaping the nature of the architect, introducing the Renaissance figure – a multi-disciplinary artist in charge. The multi-disciplinary part has faded away due to the concept of specialization in education and professions, a widely regarded concept since the Industrial Revolution and its effects on masses. However, architect's desire to stay in charge has never changed; no matter the increasing complexity of designs require teamwork of professionals throughout the realization of the project.

> *"... modernism was in essence an age of transition. Architecture needs to be well informed and restless, offering advanced personal environments."* – John Habraken (Celento, 2010)

Effects of the Second Wave on architecture peaked with Modernism and gradually we have reached a turning point where architects are teetering to break free into the new.[35] The current architectural model is unduly weighed down by centuries of outdated working methodologies (Celento, 2010), and only a few of the architects have ventured beyond.

Furthermore, the mass trends – mass production, mass marketing, mass consumption, etc. cannot be sustained in a rapidly growing world as the amount of natural resources available per person decrease drastically.

[35] Even the way this thesis is written can be considered an outdated model of writing imposed because of excessive standardization. Method used for the preparation of this thesis reminds the use of conventional CAD systems in architecture. Computers are merely used as the digitized forms of traditional tools whereas one could have designed a system consisting of hypertexts weaving different layers of writing with online streaming / fixed content, or connecting different parts of the writing to offer readers different readings.

In this manner, architecture stands at a turning point. However, some design and industrial fields have already established a new standard of production. Rising from the paradox of mass production and full customization, mass customization covers the whole range between the two poles of production systems, benefiting from both and offering flexible solutions to the producer and the consumer. Consumer becomes part of the production, thus creating unique experiences for each product. Not to be mistaken with variety, mass customization offers unique products created through configurations of modules in a considerably sustainable way.

Likewise, architecture can benefit from methods of mass customization. In order to investigate the possibilities of mass customization in architecture, the production cycle of a building should be examined in three steps: design, fabrication and use. These three steps do not represent a strict division, on the contrary successful mass customization methods should blend these three into a continuous flow.

For mass customization to flourish in architectural design, it should be included at the earliest possible stage. Even though this thesis has focused on the architect as the consumer of mass customization systems for architectural design, end-users can become part of the system passively through simulations, or actively through a direct involvement. Architects can design the most complex design with less effort as they begin to harvest the raw computational power of computers, the main reason computers were invented for. Architects must stop using computers as mere digitalized pens and become computer literate. They must form a holistic approach to the design process. For the realization of their designs, architects must become digital master builders, in other words they must be able to realize their designs in the virtual space. These tools may provide some architects the figure of authority they have desired for a long time, as long as they can prove the COMPUTABILITY=CONSTRUCTABILITY equation as mentioned by Kieran and Timberlake in order to advocate for their design.

Even though none of the CAM systems were invented with building industry in mind, together with CAD systems they can be utilized in steps for making of building elements. Even though experimental systems focusing on buildings are under development, it is highly doubtful they can be used in a feasible way.

Notion of interaction may provide users a greater level of customization in this system, yet most people are not open to interactive systems in a domestic setting. Thus, most interactive systems are limited in the public spaces.

Architecture can benefit from mass customization, however it is worth to note that mass customization is a production method primarily developed to increase the market share of a brand while attaining to the specific orders of the clients by creating unique customer experiences without compromising the brand identity, and minimizing the use of raw sources in the process. It is developed to generate desire at affordable prices. Pampered by the positive experience the consumers had with mass customization in other products, consumers might demand a similar approach from architecture. Consumers might desire architecture that revokes status, which would strengthen Starchitect's brand value.

We are already witnessing a competitive growing desire for cities or large corporations to have a signature building by Zaha, Gehry, and alike. Schumacher's attitude towards the architecture of the new age points out a possible infirmity in the way new digital design and fabrication methods affect architecture. As he willingly chooses to name all the architecture generated by these new methods *Parametricism*, he purges multiple layers of intricate design aspects into a simple phenomenon creating a danger of form driven architecture.

However, novel digital design and fabrication methods, without a thorough understanding of the tools and concepts may cause an influx of hollowed-out imitations. We are going through this stage at architectural schools. There is an inflation of projects based on *"cool looking / lame reasoning"* concepts. Most of the projects based on Voronoi can be considered as such. Observed in a small scale that of soap bubbles or cellular organization, the Voronoi diagrams are used to find and/or represent the minimum surface tension between the members of the organization. No doubt, Voronoi produces results that look intriguing compared to the rational grid structure Modernism offers, however most try to apply this to their designs without questioning whether the same paradigm which holds true for cases as small as onion cell membrane organization may still hold for the building scale. Worse is the attempt to reproduce the same without even bothering to use membranes or alike, but replacing it with steel frame structure.

Misconduct of the digital design and fabrication methods may cause a lack of trust or a cynical approach to these methods. It should never be forgotten that these are just tools created for harvesting the raw computational power of computers and place it in architect's disposal for the configuration of complex architectures. Increased level of digital design and fabrication methods use does not automatically qualify a design better. As mentioned in the thesis earlier, it would be naïve to expect all the resolutions from the advancing technology, and an extreme reliance on computers alone will cause a disappointing result.

As seen from the case studies, it is almost impossible to generalize the use of digital design methods in architecture and unify it under one name. Ironically, the architectural office Patrik Schumacher is a co-founder of merely uses these tools in their intended way. On contrary to Schumacher's claims, the era of "isms" can be over. Architecture, utilizing mass customization in design/fabrication/use phases, can move beyond the architecturally erotic forms into the functional, meaningful and sustaining while tapping into consumer desires.

The architect should be transcending into the virtual space as well, as everything that surrounds us are already in the process of becoming virtual.As the ultimate form of mass customization, design of the cyberspace provide great flexibility to the user. It is the ultimate playground for the *Homo Ludens*.

There are two levels for every human endeavor – a self-conscious, avant-garde in art and architecture as well as the advanced research in science and technology or a vernacular level where people innovate unconsciously, what Huizinga refers as the element of play, mostly taking place in the public space. As the methods discussed in this thesis are considered comparably avant-garde in architecture, these methods may seem as self-conscious, top-down dictated methods. While a certain degree of designer's decisions are necessary for the realization of any project, a thoroughly designed mass-customization should focus on the emergent un-conscious as well. When mass-customization is employed in a design, especially in architecture where the scale of the project is bigger and there is an intricate intimate bond with the product, designer's decisions should not forestall the users' will.

Although these two levels of human act may seem contradictory, they may become complimentary. The self-conscious design can benefit from the unconscious and vice versa, establishing a symbiotic link in between. Especially projects in cyberspace require a self-conscious design to kick-off. Online life simulation Second Life is coded in a self-conscious way mostly imitating real world physics. Possible relations and associations are coded rather loosely to accommodate the community's input. However, the unconscious emerges rather slower as most of the user's primary reaction is to imitate the previous reality, the reality they were comfortable with. Similar to the case with advanced computer graphics and gameplay, users are occupied with the conventional realistic aspect of the game, a replica of the ordinary. Only after they exhaust the conventional connections, they can rapidly challenge the realm and exploit the benefits the virtual environment offers.

As a society, we are at a transitional period where the effects of the Information Age alter our life at a rapid pace never seen before. Architects must co-op with these changes in order to provide desirable non-*junkspace*s. Primary results of mass customization system may not satisfy, or may prove to be inefficient. However, mass-customization is self-correcting – the new tools can also provide the architects with the chance of evaluating their design quantitatively, thus giving the architect a chance to debug.

Architect's success depends on weaving the novel design and fabrication methods into the creation of functional and desirable environments for the people evolving into the *Homo Ludens*. After all, who is better suited for the job than those who envision futures?

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| University: | Istanbul Technical University Faculty of Architecture<br>BSc in Architecture (2007)<br>Istanbul Technical University Masters of Architectural Design (2007-2011)<br>TU Delft Masters of Architecture, Hyperbody: Non-Standard and Interactive Architecture (2008-2011) |
| High School: | İzmir American Collegiate Institute (2003) |
| Languages: | Turkish (native)<br>English (fluent)<br>French (beginner)<br>Italian (beginner) |

**Experience**

Architect at Han TUMERTEKIN's office (December 2007-June 2008)
Internship at Emre AROLAT's office (July-August 2006)
Internship at construction site for Nevzat SAYIN's office (August 2005)
Internship at Han TUMERTEKIN's office (June-July 2005)
Work experience in Resit SOLEY's office (Summer 2004)

First prize in the Klinker National Design Competition (May 2007)

**Writings/Lectures**

Thesis on "Mass Customization of Architecture" (November 2011)
Series of lectures and workshops for ITU Faculty of Architecture Interior Architecture on Introduction to Parametric Design (December 2009)
Essay "theoria_poesis_praxis" published (March 2010)
Essay "cagdas_modern" (eng. *contemporary_modern*) published (March 2009)
Workshop organizer in the 9th National Architecture Students Gathering in Kayseri (2005)

**Personal Information**

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|---|---|
| Date of Birth: | 23/10/1985 |
| Hobbies: | cycling, motorcycles, scripting, DIY, LEGO |