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OUR BIM OR THEIR BIM – WHAT DOES BIM ADOPTION IN CONSTRUCTION ORGANIZATIONS MEAN?

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ABSTRACT

This paper presents a conceptual perspective of BIM ecosystems along five major dimensions. The unit of analysis was placed at a macro level to analyse the national contexts from two countries – India and Finland. To this end, the BIM ecosystem was used as a conceptual construct to describe the BIM adoption in these countries. The Product-Process-People-Policy framework was used to define the BIM ecosystems from the two countries. Further, the BIM ecosystem was characterized based on the network structure available in the countries, the key drivers of BIM, the intrinsic industry factors and the extrinsic factors for both the countries. The BIM ecosystems so described were compared and contrasted to understand the dynamics at play in the evolution of BIM ecosystems at a macro level. The comparison illustrated that the various dimensions play a major role in defining the pathway of evolution of a BIM ecosystem at a national level. Further, the framing of use of BIM in the BIM ecosystem can lead to wide variation in the meaning of BIM across the ecosystems which is name as the "our BIM – their BIM" phenomenon. We conclude with highlighting the necessity of taking the differences in the BIM ecosystem into consideration when there is an interaction between actors from different ecosystems. This is a preliminary position paper intended to start the debate of BIM ecosystems and their implications to BIM adoption in the AEC sectors.

KEYWORDS

BIM adoption, BIM Ecosystem, Innovation Management, Change Management

INTRODUCTION

As the AEC industry is taking on the challenge of implementing more complex projects on tighter timelines, the need for technology related innovations which can ease the implementation and delivery of the project is increasing manifold. As a result, the industry is looking to adopt newer technologies. This phenomenon is evident in countries across the world. Building information modelling (BIM) in construction offers one such framework to better plan, construct and manage the projects through their life-cycles. BIM promises a better paradigm of management to help better the processes in design, visualization, and coordination of team members and in facilities management among other benefits. Such promises have led to an increasing number of organizations in the AEC industry adopting BIM in their projects. From an

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organization's perspective, such adoption in an organization is complicated on a number of dimensions. First, it would usually involve shifting to a number of new technological platforms. Further, the rapid development of new technologies and BIM products introduces the dimension of rapid technical obsolescence. Second, it would involve a shift in a number of organization processes to enable BIM. Third, it might involve a change in organizational culture to go the "BIM way". Such kinds of challenges usually means the organizations closely evaluate the need for transforming to the BIM based implementation from the traditional non-BIM based approaches. Such evaluations are greatly influenced by the prevalent contextual conditions that are existing at the national level surrounding these organizations. The national contexts surrounding the use of BIM exhibit a wide variety across the world. In spite of the clearly demonstrated benefits from BIM in the construction industry, the level of BIM adoption across various national contexts show a wide degree of variation. There is a need to understand the source of such variation in the BIM adoption and how BIM is contextualized to particular national environments. Such an understanding would help researchers identify the key parameters of BIM adoption and understand how BIM would percolate and mainstream in construction industry across the world. In this study, we take the preliminary steps towards understanding the variation in BIM context from a national perspective. This paper presents preliminary findings from a research that builds on these recent efforts to build a systemic and conceptual understanding of BIM adoption and the emerging BIM ecosystem.

THEORETICAL BACKGROUND
BIM adoption would mean shifting of organization to this new ecosystem. Research in organizational studies point to the fact that institutions in which the organizations are embedded play a major role when a change/innovation – in the present case: BIM adoption – is introduced in an organization. In the BIM context, the institutional context is itself evolving where new policies and guidelines are being framed across the world. A case in example is the national BIM policy and guidelines created by U.K. Thus, increasingly organizations might also have compulsions from the wider institutional environment to adopt and mainstream BIM.

BIM adoption has been widely discussed in the literature, but barring a handful of studies (e.g. Gu and London 2010; Linderoth 2010; Succar and Kassem 2015 etc.), that provide a theoretical or conceptual perspective, most studies present either survey results or statistical data to report the status of adoption across different regions or the factors affecting adoption. For example, Gu et al (2010) discuss BIM adoption and readiness of the construction sector for various aspects of BIM tools and processes with respect to the expectations of the different stakeholders ranging from researchers, practitioners, software vendors, building owners, as well as the government agencies. Gu et al (2015) and the series of papers reported from the same research project in Australia, present a methodological qualitative analysis using a coding scheme to identify the priority issues across different AEC/FM disciplines regarding BIM adoption, and to determine the current level of awareness, knowledge and interest in BIM across the disciplines. Through the structured analysis of data collected from focus group interviews, they identify the key issues that needed to be addressed for BIM adoption.

By analysing the readiness of the industry with respect to the tools, processes and people to position BIM adoption, the authors aimed to recommend various technical,

procedural, organizational, legal and policy measures that could address the issues affecting BIM adoption. Similarly, the McGrawHill Smart Market BIM Reports (2012) present the status of BIM adoption in various markets gathered through market surveys and interviews, concluding with recommendations on how adoption could be enhanced focussing on specific issues and challenges. Several other studies (Cheng 2011; Das et al. 2011; Khosrowshahi and Arayici 2012; Wah 2014 etc.) have similarly proposed roadmaps and strategies for improving BIM adoption by specifically focusing on a list of discrete issues and factors, while making limited attempt at making a coherent theoretical or conceptual view of the adoption phenomena. While the status of adoption and factors affecting adoption are useful information, there is a greater needed to assimilate these findings to form a deeper conceptual understanding of the underlying phenomena affecting the adoption patterns?

Some notable attempts at building such a deeper conceptual understanding of BIM adoption have been made, both at the macro and micro levels. For example, Succar (2015) has focused on the conceptual structures associated with macro adoption and diffusion taking into accounts various dimensions including the role of educational institutes and authorities that can affect the policies; industry organizations, construction organizations, individuals and communities of practice that can affect the processes; and, software developers, value-adding resellers and technology advocates that can affect the technology. Based on these conceptual structures and similar initiatives, Succar and colleagues aim to create a deeper understanding of the BIM ontology and BIM framework, including the description of maturity matrices that can help organizations and agencies to have a shared understanding and language for assessing BIM adoption, diffusion, and the steps needed to address the gaps. On the other hand, Singh et. al. (2015) have proposed an emergent and co-evolutionary view of the BIM ecosystem, with the aim to create a systemic understanding of the dependencies of the different constituents of the BIM ecosystem, and how the products, processes, people and policies continuously co-evolve in such a complex system. In addition, some studies on BIM adoption have applied seminal works in areas such as diffusion of innovations (Rogers 1962), hierarchy of needs (Maslow 1943) and technological frames (1993) to understand and review BIM adoption. For example, Singh (2015) proposes a needs framework to understand BIM adoption behaviour by trying to build conceptual likes between Rogers' diffusion theory and Maslow's hierarchy of needs. Holmström et al(2014) assess adoption and evolution of BIM as a digital infrastructure in Finland through generative sociotechnical mechanisms of adoption, reuse and recombination proposed by Henfridsson and Bygstad (2013). Dubois and Gadde (2002) on the other hand review technology adoption in the construction industry, viewing it as a loosely coupled system. Thus, the need for a systemic view of BIM and technology adoption in the construction sector is beginning to emerge, including the emphasis to have sound theoretical and conceptual understanding of the phenomena.

Singh (2014) argues the need for complementary approaches to study the emerging BIM ecosystem, both at micro and macro levels. The micro-level BIM ecosystems can be studied at the level of projects, organizations and teams, while the macro-level BIM ecosystems can be studied at national, regional and global scales. As with any complex system, the micro and macro ecosystems are mutually dependent, and any such conceptual distinction is matter of the resolution of analysis and the structural patterns

of the ecosystem. Such ecosystems are usually classified based on the people, products and processes who make up BIM ecosystems. Thus, studying the evolution of BIM ecosystems at an organizational level on one hand and at a macro national level on the other hand assumes academic as well as practical significance. The comparing and contrasting of BIM ecosystems between two different countries can give the research intuitions on the various factors that influence the BIM ecosystem evolutions at a macro level. However, this have been a relatively under-studied area and provides a significant gap in our understanding of BIM ecosystems and BIM adoption in national contexts. In this study, we try to start a debate on this gap by understanding cases of BIM adoption along technical (product), procedural, cultural (people) and policy dimensions from an organizational and institutional perspective. To this end, we take the national BIM contexts (ecosystem) as the unit of analysis. By doing so, we try to understand the causes of the variation exhibited by BIM adoptions across the world.

RESEARCH OBJECTIVE

The main research objective of the present article is to understand the variety exhibited by BIM ecosystems at a national level. To this end the specific research objectives for the study are:

1. To understand the evolution of BIM ecosystem through historical perspective and the future outlook of the ecosystem along key dimensions in India and Finland.
2. To compare and contrast the evolution of BIM ecosystems in the countries.
3. To understand the key drivers for the maturity of BIM ecosystem at a macro level.

With these objectives in focus, the purpose of this article to start a debate and bring some insights into organizational research in BIM ecosystem evolution and the possible implications to national BIM policies and thus to the construction organizations which operate under these national frameworks.

RESEARCH METHODOLOGY

To answer the above research objectives stated earlier, we take the aid of case examples of BIM adoption as BIM ecosystems from around the world with specific focus on BIM ecosystem in India and Finland. We trace the history of evolution of BIM principles in the respective countries and present an outlook of the BIM ecosystems. The BIM ecosystems are explained among the dimensions of network structure, Product-Process-People-Policy (PPPP), key drivers, intrinsic factors and extrinsic factors. The history and present state of the BIM ecosystem in both the countries is presented and the future outlook of the two countries is discussed. To this end, we take the aid of the BIM ecosystem framework involving people, products, processes and policies to understand the dynamics involved in this process. We took a deeper look into the successful framing of the BIM debate at a national level to understand its impact on BIM ecosystem evolution. The qualitative comparative exploration was carried out along the dimensions discussed to generate some interesting insights into the institutional context of the BIM adoption at a national level which we discuss below.

BIM ECOSYSTEM FROM FINLAND AND INDIA

BIM ECOSYSTEM IN FINLAND

The BIM ecosystem in Finland has advanced steadily since the mid 1980s, giving it a competitive advantage. Unlike the more recent trends in countries like UK or Singapore where BIM adoption is being promoted top-down, boosted by government agencies and regulatory bodies, the Finnish BIM ecosystem evolved through self-organized effort of various stakeholders, facilitated by a conducive public research and development funding available for both the industry as well as the academia. The public R&D created the umbrella projects, which allowed the different stakeholders to develop and pilot new tools and processes at lower risks, without an authoritative mandate. The financial crisis in the 1980s provided timely opportunity for experimentation as the industry needed new ways to come out of the crisis, and create new productivity gains. The availability of high skilled personnel from technical and research background, combined with a close-knit network of industry and academia facilitated the development. The initial projects led to maturity of the leading BIM software vendors, which in turn further created new opportunities for growth and development of various aspects of the ecosystem, creating a positive growth cycle and commitment of resources to BIM development. However, as noted by Holmström et al (2014), while the initial projects started with the objective of improving lifecycle management of built projects, as also envisioned by the government real estate owners, the tangible benefits observed by the contractors in the design and construction phase, fuelled the R&D on tools for design coordination, detailing, and production management. The growth of BIM has remained steady since then, however, not necessarily seeing the steep curve seen in some other parts of the world such as UK or US. Consequently, while Finnish BIM ecosystem has grown, the leading BIM software from Finland have been acquired by larger global groups, which are targeting global markets more aggressively than the Finnish companies. Hence, the outlook for future remains positive even though the unique competitive advantage gained as a pioneer may not necessarily hold the same weightage. Nonetheless, the factors such as high average technical and research skills, extended practical experience with BIM, new technical innovations are expected to create new opportunities for growth of next generation of BIM tools and processes in the Finnish BIM ecosystem. Table 1 presents the key descriptions of the BIM ecosystem in Finland along the major dimensions discussed earlier.

Table 1: BIM ecosystem in Finland – history, present and outlook for future

Ecosystem-Finland	History and present	Outlook
Network structure (BIM/ Construction)	Small network size. Most actors have known each other. Despite lack of formal alliancing, BIM related effort has been more cooperative than competitive, strung together by government supported R&D projects.	Competitive advantage is partly alleviated with increasing global ecosystems and networks of software vendors. In contrast, the core construction companies and their network has remained local. This create

		a mismatch that did not exist earlier.
PPPP dimensions	**Products:** Leading software vendors that have had global influence in design coordination, detailing and production management. Products also along performance management. Played critical role in development open standards and compatible tools. **Process:** Software focus on improving efficiency of built environment, driven by recession and tough environmental conditions. Initial focus on production efficiency, quality of construction and coordination. **People:** High average technical and research skill. Tight-knit network. **Policy:** Neither top-down, nor bottom-up. Collective effort, through conducive research-driven environment. R&D policy and strong industry-academia partnership.	**Products**: Leading Finnish software vendors have been acquired by international groups. Focus shifting toward next generation start-ups and technologies. **Process:** BIM R&D still focuses on existing areas of strength. However, other technologies are being assimilated, but global environment is more competitive than before. With increasing maturity on tools for design and construction, focus increasing on use phase. **People:** No major change in people **Policy:** No major change in policy.
Key driver(s) (Industry/ research/ academia)	-Government funded R&D projects -Recession and financial crisis in late 80s and early 90s -Champions and industry leaders -Public building owners as visionary customers	- No major shift in drivers - Internationally more competitive environment than earlier -
Intrinsic factors (industry)	- Small network size - High technical skill - Strong industry-academia collaboration	-Local demand and challenges are limited compared to international markets. More global outlook needed. - Local construction technologies and production systems are fairly uniform. Greater spread in international markets.
Extrinsic factors (outside construction)	-high average technical and research skill in Finnish society - Financial conditions in 80s and 90s, and again in recent years -demanding local conditions requiring high quality construction and efficient buildings in use	- No significant change besides a more competitive international market. The unique leadership position enjoyed earlier is no more applicable.

	-Focus on export of expertise to international markets: explains why only BIM and software related companies from construction have gone international, while core construction companies have remained largely regional	

BIM ECOSYSTEM IN INDIA

The BIM ecosystem in India presents an interesting contrast to the happenings in Finland and elsewhere in the world. The Indian ecosystem in BIM has evolved over the last two decades. In this sense, India is a little late comer to the BIM party as compared to other countries. Traditionally, in India the construction sector has been predominantly a labour intensive and highly fragmented industry. The industry is characterized by conventional norms and practices with an averseness to the innovations. The digitalization of the construction processes are a little late to take off. The reasons range from the lack of skilled manpower to financial investments required to adopt new technologies. However, with the emergence of technologies on one hand and the need to innovate and incorporate new processes to increase the efficiencies to meet the ever increasing demand for construction in the country, the adoption of BIM has started off in the later part of the last decade. The evolution of BIM ecosystem here is more organic than coercive mandated policies from the government or the regulatory bodies. In fact, the clarity on how BIM should be tapped and used on the construction projects and in AEC sectors is missing from the policy frameworks of the country. The globalization during the early 21st century and the increasingly global nature of project being implemented in the country forced the construction sector to relook at the construction practices in the country. The major construction companies which started to work with foreign consultants and contractors on complex domestic projects as well as worked on projects abroad have realized the need of BIM and digitalization in the construction industry. The active involvement of academia to provide the forums of discussion on the benefits of BIM has helped further. The evolution path of BIM in the country therefore has been a more debated one where the companies picked and chose the components of BIM suited to their needs. The initial notion that BIM is just another digital drafting tool with 3D visualization capabilities are slowing vanishing and other uses of BIM are being utilized right now. However, the maturity levels of BIM capabilities vary widely among the construction organizations in the country. The larger organizations have taken up BIM in a very inclusive manner and are developing huge inhouse capabilities in terms of skilled manpower to utilize BIM on projects. The medium and small companies are still evaluating the use of BIM to the organizations. The financial investments required to acquire the latest product licences are proving to be barrier in the country where the immediate returns on the investments are usually demanded by the top managements to justify the introduction of BIM platforms in the organizations. The network between the various stakeholders in the country is a loosely coupled one. The interaction is present between various stakeholders like academia, industry, government agencies, consultants and BIM product developers. However, gaps remain in such interaction and all the stakeholders are realizing the issues with

these gaps. Hence the present outlook of the BIM is a mixed one in the country. The BIM is getting increasingly adopted albeit in a cautious and evaluative manner by the industry. The outlook could remain the same in the near future, where there was no likely regulatory top down approach being adopted by the government. However, avenues are being created for more research in this area and the need for interaction among the various stakeholders is set to increase. Further, the skill sets required for technical professionals in BIM are now being mainstreamed into curriculums which would have an effect on the "BIM-readiness" of the workforce in the future. Table 2 presents an overview of the BIM ecosystem as present in India.

Table 1: BIM ecosystem in Finland – history, present and outlook for future

Ecosystem- India	History and present	Outlook
Network structure (BIM/ Construction)	The networks related to BIM are virtually non-existent. The networks related to construction industry is highly fragmented. The professional networks of the construction industry professionals had focus on other aspects than BIM in the past. Now, BIM is one of the key areas but not yet on high priority for the companies.	The outlook for networks involved in BIM and construction might slowly gain momentum. Some initiatives in this direction are being taken the software product vendors to create training networks, academies to make construction professionals understand and appreciate the uses of BIM on complex construction projects.
PPPP dimensions	**Products:** Products available are largely proprietary with large subscription and installation fees. The common vendors of BIM are all actively competing for market share in the BIM space in India. However, the investments remain beyond affordable to medium and small scale firms in the country. The industry is generally sceptical about what the products promise and what they actually deliver. **Process:** The traditional Indian processes are usually hierarchical in nature in the construction industry. The coordination and collaboration which become key in BIM implementation is right now evolving in the industry. The paradigm shift where the processes allow sharing of information among various team members is still maturing. **People:** There is a wide variation in the skill level of the people	**Products**: The need for newer and economical software products. The need for open source BIM platforms with seamless integration with the existing systems is present. **Process:** BIM R&D still focuses on existing areas of strength. However, other technologies are being assimilated, but global environment is more competitive than before. With increasing maturity on tools for design and construction, focus increasing on use phase. The processes would evolve towards a more decentralized and digital basis thus encouraging the use of BIM. **People:** A larger number of people are getting trained in BIM related areas. The scarcity of the technically adept

	available to construction sector in the country. While some of the larger companies enjoy the benefit of employing persons with high technical skills, this skill level varies significantly with the size of the organization. While some companies have tie-ups with leading universities of the country to train and skill the employees on skills like BIM, other companies are not enthusiastic about such activities. **Policy:** The government policy towards BIM has so far been minimal in mandating the use of BIM. The government is allowing an organic bottoms up approach for the evolution of BIM in the country. No specific legislations or policy directives exist in the country to mandate use of BIM in any projects in the country.	professionals might ease in the future. **Policy:** No major change in policy is envisaged.
Key driver(s) (Industry/ research/ academia)	- Clients who mandate use of BIM - The foreign customers and the contractors who tie up with the industry - Indian contractors taking global construction assignments - The academia in disseminating the benefits of using BIM.	- No major shift in drivers except that the clients might mandate the use of BIM more frequently on projects in future. - Internationally more competitive environment than earlier -
Intrinsic factors (industry)	- Large variation within the construction industry - Highly fragmented professional networks within the industry - Cost sensitivity to the investments in BIM	-Local demand is the key to increase the adoption of BIM in the Indian market. - Challenges from international market and more global outlook might lead to further adoption.
Extrinsic factors (outside construction)	- Wide variation in technical skill of people. - Minimal government involvement in driving BIM	- more competitive international market.

DISCUSSION

The comparative study of the BIM ecosystems along the dimensions illustrated earlier yielded some insights into the BIM adoption at a macro scale across countries. We discuss these insights now.

THE TOP-DOWN OR THE ORGANIC APPROACH TO BIM ADOPTION

Organizations usually resort to BIM adoption in predominantly two ways. First, the organizations realize the need to adopt BIM due to the increasing demand for BIM related services from the AEC community and the clients of the construction projects. This we coin as the organic approach to BIM adoption. Second, the organizations feel compelled to adopt BIM due to policies and guidelines framed to enhance/mandate the use of BIM in construction projects. This we refer to as the top-down approach to BIM adoption in construction organizations. We do not have sufficient evidence to point out which approach is better or worse for BIM adoption. However, more interestingly, we find certain similarities in organizational framing of BIM in both the cases. Both the approaches require intense internal organizational framing of the uses of BIM adoption to convince the actors in the organization to change to the new BIM ecosystem. At a macro scale, the government and its policy might play a major role in coercing the organizations to use BIM on projects. This was not observed in both the Finnish and the Indian BIM eco-systems. However, the trajectory adopted by both the countries are contrastingly different. While the Finnish construction companies realized the use of BIM at a very early stage and adapted it to the industry norm, the Indian construction companies were more cautious in adopting this innovations. This points to the nature of innovation diffusion in both the countries. While the Finnish companies are early adopters with respect to BIM, the Indian companies can fall under late majority or laggards in adopting this innovation. The reasons why the countries have exhibited such behaviour is beyond the scope of the present study due to lack of sufficient data from the countries to analyse this. However, a look at the drivers of the BIM ecosystems point to the fact about the needs of the industry in each of these countries to be different which might explain the evolution paths of BIM ecosystems. Financial viable technologies with the availability of high skilled workforce could have helped Finland to become early adopters to test the innovation and satisfy the needs of the industry. Whereas, the cost focus of the Indian construction companies combined with barriers to affordable and reliable products in BIM could have proved barrier to BIM adoption in India. From the above discussion we present the following proposition

Proposition 1: Even with similar approaches adopted in the evolution of BIM ecosystem, the evolution of ecosystem depends on the key drivers of BIM and the context in which the BIM ecosystem is evolving.

OUR BIM VS. THEIR BIM

One interesting finding is that these framing processes usually create different meanings of BIM itself in the organizations. Organizations with exposure to BIM and who are convinced of the need for BIM adoption (both due to external or internal factors to the organizations) play a key role in framing these debates. Such organizations usually debate the merits and de-merits of BIM and what it means to adopt in their organizations. In this process, they usually frame the very meaning of BIM in a way that is beneficial to the organization and in a way intended to aid in

successful adoption in the organization. The outcome of such intense internal debates in a BIM ecosystem is wide varying meaning of what BIM is. Though limited evidence in this area, we observe this difference is quite marked in the ecosystems of Finland and India. While BIM was framed as a new paradigm or innovation in construction which is the need of the hour in Finland to mainstream it, the framing was quite different in India. In the Indian BIM ecosystem, BIM was predominantly framed as a tool to improve visualization (3D) of the project and an extension of the CAD to further digitize the construction drawings. Thus the predominant understanding of what BIM means to Indian ecosystem is vastly different from what it means in the Finnish BIM ecosystem. This fundamental difference in the framing of meanings can have huge implications on the behaviour and future course of evolution of BIM ecosystems in the countries. Further, such differences become extremely important to be addressed when the actors from one eco-system interact with actors in another ecosystem. Thus, when the contractors or owners from one ecosystem take up projects or form consortiums with contractors/owners from another ecosystems, it is important to address the issue of this difference between the BIM meanings in the two ecosystems. Though we do not have empirical evidence at this point in time, it can be deduced that there would be a need to have boundary spanners of the two ecosystems who can make such interactions possible in a productive manner. From the discussion so far, we present the following proposition

Proposition 2: The framing of BIM use in an ecosystem can lead to a widely different interpretation on what BIM means in an ecosystem as compared to other ecosystems

Proposition 3: The boundary spanners across BIM ecosystems can play a major role in reconciling the meaning of BIM thus setting the expectations when organizations from two BIM ecosystems interact.

IMPLICATIONS AND CONCLUSIONS

This study presents some interesting implications to researchers as well as construction organizations. From an organizational research perspective, the BIM ecosystem provides an important framework to understand the change processes involved in BIM adoption. The actor/structure and the organizational framing of BIM meaning and uses play an important role in the adoption of BIM. From the practice perspective, construction organizations should be aware of the differences in what exactly BIM means in different organizations when there is an inter-organizational conversation on BIM. This becomes particularly significant when there are international firms which either team up or contract BIM related services. Such cognizance of the differences would enable better communications between organizations. Further, such an understanding would give the organizations insights into the BIM capabilities of the other organizations involved in a project. The present study is intended to start this debate on the need to study the adoption of BIM from an ecosystem perspective. This study is limited by the amount of empirical evidence available to formulate the prepositions discussed earlier. Further studies and research is required in this area to better understand the use and impact of BIM and its adoption in construction organizations.

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