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BIM benefits and its influence on the BIM implementation in Malaysia

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ABSTRACT

Building Information Modelling (BIM) implementation is considered a daunting reality because majority of the construction players don't know the potential benefits of the technology. Awareness of BIM benefits and its implementation could significantly increase project productivity and performance. This study is aimed to determine the influence of BIM benefits from the Malaysian construction stakeholders' perception towards its implementation. The study was carried out using survey questionnaire. Out of 590 questionnaires 268 were collected that represent a sample size of 346. Results revealed that most of the construction companies lack of awareness about BIM technology. The statistical analysis showed that productivity, time, cost, clashes, and communication are the most essential BIM benefits that concerned the participants. The driving factors of implementation, on the other hand, were identified as Trust, respect, commitment, early involvement, and knowledge. It is also found that there is a significant relationship between BIM benefits and its implementation.

1. Introduction

Construction projects processes are disintegrated in nature with a complex life cycle. They are built-in sequence phases that is from the initial phase of a project to its possible demolition that postulate a bulky documentation and information. The reality of construction projects impose the interaction and integration of different professionals from different organizations to perform defined tasks within the scope and objectives of the project. The presence of bulk documents and sharing of fragmented information among the project stakeholders lead to the following: misunderstanding usually arise, frequent verification and clarifications are often required, disappointment, lack of trust and conflicts among them. As a result, of the aforementioned problems, the traditional goals (i.e. time, cost and quality) and productivity of a project are usually affected. According to Crooty [1] poor standard of information is the main issue of poor performance in the construction industry. Therefore, the improvement of information quality between stakeholders should be of the highest possible standard to ensure the effective performance of the construction industry. Two key challenges were identified by Crooty [1] to cope with the intensive information, the quality of the information generated, and how this information would be communicated. However, the BIM-based design technique promises to reduce the complexity and difficulty of project management [2]. Thus, the construction industry tended to transform from the conventional construction practices to the BIM-based practices.

Now, with proper adoption and implementation of BIM, complexities and difficulties in managing a project would be reduced drastically [2]. BIM enhances the current communication process, provides a collaborative platform, and supports interoperability between the different business domains [3–6]. In addition, BIM can increase the performance and enhance the productivity

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throughout the project life cycle if implemented successfully [7–11]. It is seen as an innovative technology that represent buildings in a 3D geometric objects, interrlates the objects to one another, and integrate them with valuable information such as cost and time. This model could be maintained for updating and reviewing throughout the project cycle and its life usage.

This paper presents the influence of BIM benefits on construction practitioners' decision toward its implementation. The main aim of this research is to prioritize the BIM benefits according to the Malaysian stakeholders' perception and develop a theoretical map of how those benefits could drive them toward BIM adoption and implementation. Correspondently, the objectives of the study are as follows:

1. Identify the most significant BIM benefits that influencing its implementation in the Malaysian construction industry,
2. Scrutinize the relationship of the BIM benefits according to the construction industry stakeholders' perception to enhance its implementation.
3. Validate the significant antecedent BIM benefits on its implementation.

No comprehensive research has been conducted in the past to evaluate the perception of the Malaysian construction players toward the concerned benefits that influence their decision when adopting BIM. However, the content of this research will enhance and provide awareness to professionals and researchers to understand the most concerned benefits to help increase the BIM adoption and implementation in Malaysia.

However, effective implementation has always ensured the achievement of benefits and vice-versa. So, BIM benefits should influence construction industry practitioners to implement BIM. This research develops a hypothesis that there is a significant relationship between BIM the benefits and the BIM implementation which could influence the Malaysian companies/organizations to consider the BIM implementation as shown in Fig. 1.

2. Literature review

2.1. Background of BIM

BIM also known as n-D modeling, virtual model, or virtual prototyping technology can be defined as a collaborative platform to process, produce, communicate, and analyze the construction projects using a digital information model throughout the project construction life-cycle [11,12]. BIM according to Oraee et al. [6], is defined as "a methodology with technological, agential and managerial components". It was innovated as a result of integrating Information and Communication Technology (ICT) in construction industry [4,13]. BIM was developed in the early 2000s in Architecture, Engineering, and Construction context [4,11,14]. It was created as a result of integrating Information and Communication Technology (ICT) in the construction industry processes [4,13]. Since then it has been acknowledged as a catalyst for innovation and productivity in the construction industry [15]. It was also developed to solve the issue of collaboration [5,16], coping with intensive information [1], reduce project time and cost [14], and improving construction performance [4,14]. It also supports the green building assessment and analysis [17]. In addition, it is rated as an effective platform that provides less harmful buildings to the environment, minimizes construction industry risks [16], resolves complexity, and eliminates project management conflicts [2].

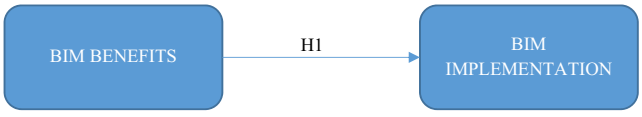

Fig. 1. Influence of BIM Benefits on the BIM Implementation.

As is can be seen clearly, there is a Consensus among previous researchers and industry professionals that BIM technology can improve productivity and efficiency, enhance constructability, minimize errors, and saved time and cost. These aforementioned attributes this assists in delivering a more sustainable construction process [15,18].

Several interpretations provided by previous researchers that could illustrate the benefit of BIM. Some of them are as follows:

> "BIM is a new approach to manage building design and project data in digital format throughout a building's life cycle that provides the exchange and interoperability of information among the stakeholders." [16]

> "BIM was first introduced in the AEC industry to encompass all design aspect, construction, and operation of the building." [12]

> "BIM offers the stakeholders collaboration at different stages of a building's lifecycle, enabling them to insert, extract, update, or modify information during the BIM process." [3]

2.2. BIM awareness

The awareness of BIM implementation process, its benefits, and its challenges were highlighted by many researcher as an important aspects to encourage the industry to adopt it as a new method for delivering the projects [19–23]. Memon et al. [20] revealed that the lack of awareness is the reason for the slow adoption and implementation in Malaysian. Awareness has raised a non-exhaustive list of challenges to the BIM adoption and implementation such as; trusting new technology [9,13,19], building BIM skills [9,10], proper BIM-based tools selection [24], understanding the BIM project scope, and handling contracts [25,26]. Therefore, increasing awareness will help overcomes challenges affecting BIM adoption and implementation and consequently benefiting from this technology [27].

2.3. BIM implementation

The implementation of BIM added significant benefits to the construction industry, but at the same time it has a significant impacted on its current practices, contractual policy, and business model. This made industries and organizations to reshape [11,14]. BIM implementation incorporates a range of challenges and they include the following: technical challenges [3,4,11], management challenges [11], and environmental, financial and legal risks [3,4].

The relationship between the construction industry and practitioners is described as a push and pull relationship [13,14]. This relationship explains the need for initiating the BIM adoption to promote information among parties, increase awareness, and enhance its readiness to be implemented in their work environment [10,14]. The government plays the main role in promoting the BIM implementation [11]. BIM implementation requires early involvement of all the stakeholders [13]. Interoperability supports collaboration, and personal commitment, motivation, and practitioners behavior increase the diffusion of BIM [2]. Governmental policy is viewed to be in line with the construction stakeholders' perceptions of the value gained by the BIM implementation. Therefore, this research believes that the BIM implementation should focus on how organizations can achieve their concerned goals with minimal losses and/or in a short period.

2.4. BIM benefits

BIM technology is considered as a new platform for delivering construction project [4]. BIM technology is an innovation that adds valuable benefits to deliver construction domains throughout the project lifecycle [2]. Utilizing BIM throughout the project lifecycle supports the concurrent construction [14]. Certainly, it can also facilitate development stages of a project lifecycle [5,28–31] from the early conceptual phase through design, construction and operation phase to demolition [4,31].

Several researches identified the important benefits of BIM implementation to enhancing productivity and increasing efficiency. The main benefits of BIM implementation are enhancing productivity and efficiency. BIM has the ability to integrate time and cost which supports real-time update and assesses efficient tracking and monitoring process along the project phases [32–34], BIM can also be applied in the assessment and analysis of green building [17]. It can also be used for clashes detection and design optimization [35,36].

The ability to apply BIM in different management processes and analyses make attainment of high performance possible in construction industry. Understanding and acknowledging the value of BIM make construction players' decision to use BIM for their projects very easy. However, to achieve that, it is important to identify and convince the players the benefits of the technology provide.

3. Methodology

Similar to other researches, BIM benefits and its implementation factors were identified through intensive literature review for the design the formulation of survey questionnaire [21,25,26,37,38]. The questionnaire was designed to fulfil the objectives of this research including awareness of the BIM implementation, the concerned BIM benefits, and the BIM implementation success factors. The data collection took place in Melaka, Kedah, Sabah, and Sarawak state in Malaysia. The participants for the survey were clients/developers, contractors, consultants, participants from Construction Industry Development Board (CIDB), and MYBIM center from Private and public organizations with different background and experience give a unique diversity in the research result.

A sample size of 346 was obtained from a total respondent population of 3533 using Morgan's table for determining sample size from a given population [39]. Out of 590 survey questionnaires that were distributed, only 268 valid ones were retuned. The precentage of the returned questionnaire is around 77% which is acceptable limits by Akadiri, 2011 [40].

The valid responses were descriptively analyzed. It was found that the despondence rate from Kedah and Sarawak represented 38% and 31% respectively while only 17% and 14% responded from Melaka and Sabah respectively. According to the returned questionnaires, contractors responded at rate of 54% as the highest, followed by clients/developers with 20%. Civil and structural engineer, architects and Mechanical, Electrical, and Piping engineers (MEP) scored 9%, 4%, and 2% respectively. There were other respondents from academic sectors, management and government representatives with 11%. Overall the number of companies and organizations that participate in the research is satisfactory because a sample size of 200 respondents is adequate for a statistical power of covariance structure models such as Structural Equation Modelling (SEM).

4. Results and discussion

4.1. Awareness of BIM

It seems that the BIM awareness level is still low in Malaysia. Five levels of participants' awareness were assessed as presented in Table 1. Level three (moderately aware) was considered as the acceptable level of awareness. The highest moderately awareness level was found to be in Melaka with 39% then Kedah and Sabah with 21% and 28% respectively. The total respondents who were above the level moderately aware of the BIM technology in all the states were around 45%. However, the highest percentage indicated a low awareness level (slightly aware and not at all aware) in all the States and the total was around 56%. Overall, the result showed that awareness level in Malaysia is very low. Nevertheless, there is a great opportunity for the Malaysian construction industry to increase the level of awareness through the yearly organized program such as seminars, exhibitions and workshops. This strategy has proven its excellence to promote the BIM application by encouraging the local organizations to shift from the conventional construction practices to the BIM-based technology. For a successful shifting, this research evaluates the most important benefits that influence the stakeholders' decision to initiate the BIM implementation.

4.2. BIM benefits

Descriptive analysis was carried out to rank the importance level of the identified BIM benefits based on their mean values. Some researchers used the mean value of 4 as a cut-off to identify the significant factors [41]. Similarly, this research adopted the same value. The results showed that only 7 benefits out of the 18 identified benefits were ranked as significant with a mean value greater than 4. All the significant benefits showed a standard deviation below 1 which represent a good accuracy of the collected data. Accordingly, a *t*-test was used to identify the most significant benefit among the 7 benefits as used by Yunus et al., 2019, Ofori and Kien, 2010, and Ekanayake and Ofori, 2004 [41,42], and [43]. In this study, the null hypothesis (benefits were neutral, insignificant, and very insignificant) is accepted if the t-value is smaller than 2.10 (the critical t-value).

The significant benefits were increase productivity and efficiency, assess time and cost associated with design change, and eliminate clashes in design" as shown in Table 2. However, this research adopted the top 7 benefits that are significant according to the mean of $\geq$4.00.

The result from the Kruskal-Wallis one-way ANOVA test to determine whether differences between stakeholders perceptions. We want to test the null hypothesis that population medians are equal, versus the alternative that there is a difference between at least two of them [48]. Test revealed that no significant difference between the stakeholders' perception on the 7 essential benefits. One benefit that the null hypothesis was rejected and there was a slight differences across the key stakeholders in integrate construction scheduling & planning this benefit. The difference was found to be in clients/developers group.

The outcomes demonstrated that all the 7 advantages can be factually considered as the most critical and significant to influence the decision on the BIM implementation. Other benefits for example, collaboration with other teams, facilitate site planning analysis, increase sustainablility, promote transparency and interoperability, support safety management, and energy efficiency analysis were ranked below the cut-off mean. A successful case study illustrating the possibility to achieve those benefits through the BIM implementation could motivate and increase the BIM implementation. Since the respondents were from different organizations, backgrounds, and experiences, their opinions and views are very important to stimulate their concerns when promoting the BIM projects. Therefore, the 7 significant benefits selected and ranked as important will provide a sound basis upon which decision-making guidelines for the BIM implementation can be based.

Table 1
Awareness of BIM.

		Melaka %	Kedah %	Sabah %	Sarawak %	Total %
Awareness	Not at all Aware	4	28	25	22	22
	Slightly Aware	41	26	31	42	34
	Moderately Aware	39	21	28	19	25
	Somewhat Aware	13	17	17	12	15
	Extremely Aware	2	8	0	5	5

Table 2
BIM Benefits Influence Malaysian Companies to Implement BIM.

No.	Important benefits	Mean	Sd	t-value	The important benefits identified were also supported by the below listed researchers
B1	Increase productivity and efficiency	4.08	0.78	2.72	[5,7,15,18]
B2	Assess time and cost associated with design change.	4.07	0.84	2.26	[9,10,44]
B3	Eliminate clashes in design.	4.07	0.77	2.37	[35,36]
B4	Improve multi-party communication and maintain synchronize communication.	4.02	0.77	1.57	[8,45]
B5	Integrate construction scheduling & planning.	4.01	0.75	1.43	[32–34]
B6	Identify time-based clashes.	4.01	0.79	1.36	[36]
B7	Monitor and track progress during construction.	4.00	0.81	1.16	[46,47]

The observation during the data collection found that the construction industry face a serious problem in term of construction conflicts. As a result, project delay, cost overrun, and low-quality is experienced. Practitioners acknowledge the benefits of BIM to the construction projects, but they are reluctant to adopt it. Some construction players believe that the construction industry should enforce the application of BIM, while others comment that the industry should provide evidence on how construction players could implement BIM to achieve the desired benefits. The identified benefits are well known but prioritizing them is important to understand the players' perception regarding the BIM implementation. Interestingly, the highest-ranked benefit "increase productivity and efficiency" was found to be in line with the Construction Industry Transformation Program 2016–2020 [49] of promoting BIM in construction projects. Moreover, governmental policy is viewed to be in line with the stakeholders' perception of the value gained from BIM implementation. Therefore, this research recommends that the BIM implementation should focus on how organizations can achieve their concerned goals with minimal losses and/or in a short period.

4.3. BIM implementation

Similarly, to the BIM benefits, the BIM implementation success factors were ranked according to their mean values. A total of 24 factors were ranked as significant and very significant. The standard deviation was below 1 and this represent a good data accuracy. Accordingly, a *t*-test was used to identify the most significant factors among the 24 benefits. The null hypothesis (factors were neutral, insignificant, and very insignificant) is accepted if the t-value is smaller than 2.01 (the critical t-value). The very significant factors were "mutual trust, respect, and personal commitments to cooperation", "early involvement and participation of project teams", and "early selection and capability to use appropriate BIM software tool to perform the task" as shown in Table 3. However, the results showed that 3 factors can be statistically considered as the most significant and relevant for the initial success of the BIM implementation.

According to The Kruskal-Wallis test, the results revealed that the null hypothesis that the distribution of the factors are the same across different stakeholders is rejected for mutual trust, respect, and personal commitments to cooperation with significant difference between clients/developers and other respondents, and retained in the other two factors knows as "early involvement and participation of project teams" and "early selection of the appropriate BIM tools to perform the task".

The factors above are essential for initiating the BIM implementation. It was observed that the mega organizations have a great chance to maintain those factors and successfully implement BIM faster than the Small and Medium- Enterprises (SME). This is because the mega organizations have their own different departments such as architecture, engineering, and construction departments' makeing it easier to work in the same environment, trust each other, cooperate, and collaborate. Therefore, those organizations value the benefits of BIM. However, SMEs have different interest, and each party focuses on its own benefits rather than the project success, so they usually face difficulties to meet the requirements for the BIM implementation. Even though they acknowledge the BIM benefits but they believe that the interests will not be equal.

4.4. Measurement and structural model

A measurement model demonstrates the existing relationships between items and their underlying latent construct. The fit values for both measurement and the structural models must fall within at least one of the three fit index categories named as absolute fit, incremental fit and parsimonious fit [52]. The minimum thresholds of indices in measuring the measurement and structural models are shown in Table 4.

The statistics in Fig. 2 and Table 5 show that the measurement model had a Root Mean Square Error of Approximation (RMSEA) value of 0.016 (acceptable), Chai square (CMIN) of 65.831, and degree of freedom (df) of 32. The Comparative Fit Index (CFI) of 0.979, CMIN/df of 2.057, Standardized Root Mean Squared Residual (SRMR) of 0.016, and Close Fit (Pclose) of 0.077 were within the excellent interpretation of the threshold value. Therefore, the fit statistics are adequate within the acceptable thresholds and factor loadings to establish convergence validity of the BIM implementation. The correlation occurred between the BIM benefit and its influence on the BIM implementation was 0.24. However, the structural equation model in Fig. 3 and the resulting path test of two-tailed significance in Table 6 revealed that the BIM benefits had a significant impact of 0.49 on the BIM implementation.

Table 3
BIM Implementation Factors.

No.	Factors	Mean	Sd	t-value	The BIM Implementation factors identified were also supported by the below listed researchers
BI1	Mutual trust, respect, and personal commitments to cooperation	4.07	0.71	2.49	[50]
BI2	Early involvement and participation of project teams	4.06	0.72	2.26	[3,15,18,23–26]
BI3	Early selection and capability to use appropriate BIM software tool to perform the task	4.05	0.674	2.24	[22,24,25,51]

Table 4
Cutoff Criteria [52,53].

Measure	Terrible	Acceptable	Excellent
CMIN/DF	> 5	> 3	> 1
CFI	<0.90	<0.95	>0.95
SRMR	>0.10	>0.08	<0.08
RMSEA	>0.08	>0.06	<0.06
PClose	<0.01	<0.05	>0.05

Table 5
Model Fit Measures.

Measure	Estimate	Threshold	Interpretation
CMIN	65.831	–	–
df	32	–	–
CMIN/DF	2.057	Between 1 and 3	Excellent
CFI	0.979	>0.95	Excellent
SRMR	0.016	<0.08	Excellent
RMSEA	0.071	<0.06	Acceptable
PClose	0.077	>0.05	Excellent

5. Conclusion

This research investigated the influence of BIM benefits on the Malaysian construction stakeholders' decision on the BIM implementation. The study carried out through the identification of the important benefits and factors affecting the initiation of BIM implementation. A questionnaire survey was the basis of this research. A sample size of 346 was obtained from a total respondent population of 3533. Around 590 survey questionnaires were distributed and only 268 were returned as valid ones. The results revealed that the diffusion of Malaysian construction companies to BIM implementation is very low. So, it is necessary for the construction industry to promote BIM based on the practitioners' interest. From the descriptive analysis, seven important benefits identified as significant to stakeholders' decision were; increase productivity and efficiency, assess time and cost associated with design change, eliminate clashes in design, improve multi-party communication and maintain synchronize communication, integrate construction scheduling & planning, identify time-based clashes, and monitor and track progress during construction. These benefits significantly influenced the practitioners' decision to enhance mutual trust, respect, and personal commitments to cooperation, get early involve and participate with other project teams, and early selection and build capability to use appropriate BIM software tools to perform the task. Although the evaluation of the BIM productivity is complicated, case studies are often necessary as evidence to present the BIM efficiency. A successful case study illustrating the possibility to achieve practitioners' benefits through the BIM implementation could motivate and increase the BIM adoption. There is an agreement regarding the BIM benefits and the implementation requirements. Therefore, this paper suggests that the Malaysian construction industry needs to enhance the relationship between practitioners. It should focus on a local case study as evidence that BIM can help them achieve their goals and providing strategies for successful transformation.

In addition, SMEs organizations are recommended to identify their strengths to initiate the BIM implementation, and encourage professionals to develop their capability. Industry is recommended to focus on a local case study as evidence that BIM can help them achieve their goals providing strategies for successful transformation.

Based on the findings, this research recommends the construction industry to enhance construction practitioners, especially SMEs, to build trust, respect, cooperate, and participate through involvement to successfully implement BIM. The impact of the parties' interest to the BIM benefits should be clarified for every party involved in the project. It is a good strategy that the construction industry focuses on a case study that involves local SMEs to identify the BIM implementation issues and difficulties. The government should devlop a framework of parties' participating in the project to illustrate how they can meet their desired benefits. Benefits presented in this research could be used as a good reference to reflect the practitioners' thoughts and how they influence the essential factors for a successful BIM implementation.

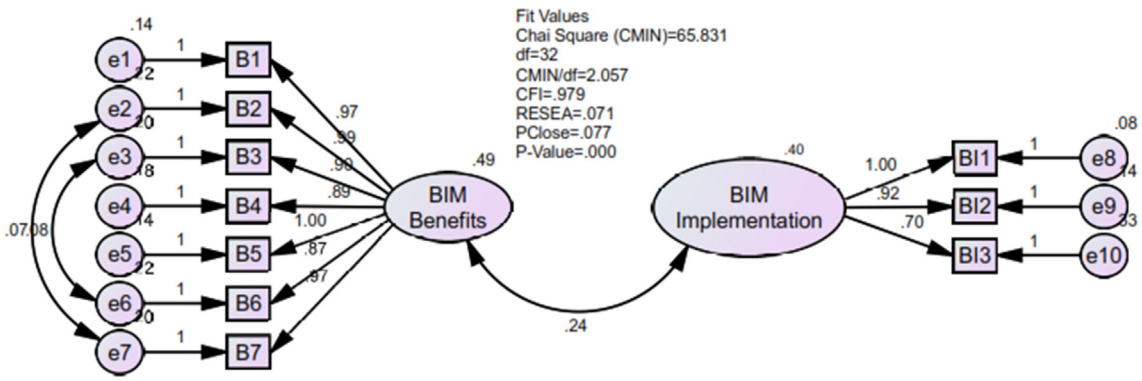

Fig. 2. Influence of BIM Benefit on the BIM implementation measurement model.

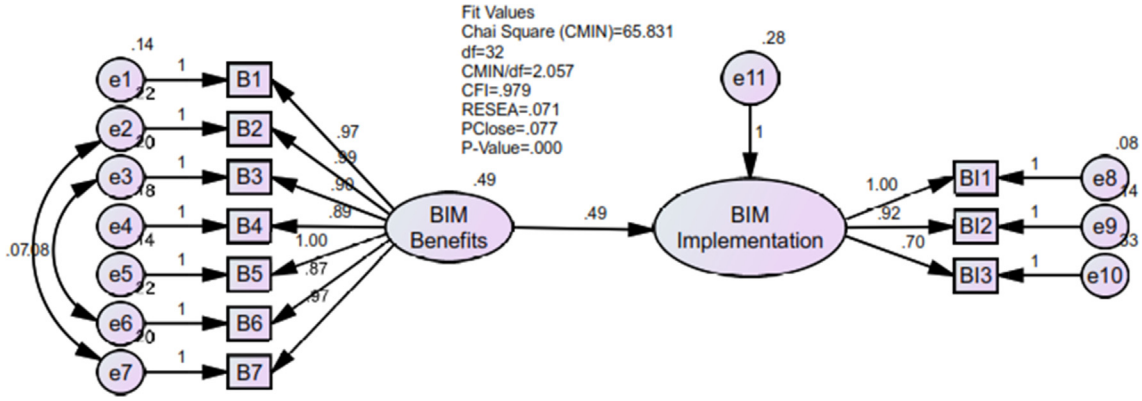

Fig. 3. Influence of BIM Benefit on the BIM implementation structural model.

Table 6
Hypothesis Testing.

	Estimate	S.E.	C.R.	P	Label
Implementation <— Benefits	0.492	0.064	7.741	0.000	significant

Authors found that there is a relationship between BIM benefits, its success factors, and its challenges which affecting BIM implementation. Since this research covers only the benefits influence BIM implementation, future work will be focusing in the influence of BIM challenges to BIM implementation and Success factors to BIM implementation then future research will provide a comprehensive framework for effective BIM implementation.

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