An Investigation of Interactive Environment Design Constraints

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Abstract

Creating interactive environment for public is a complex task, as designers have to manually adhere to various considerations, especially with involvement of stakeholders from divers background. In real world, the quality of a design result is generally determined by the degree to which compliance constraints have been reached. In contrast to most research about design constraints on technic application, user interface, or architecture, scanty study has been conducted on the constraints of environment design that synchronize interactive experience from comprehensive perspectives. As technology evolves at tremendous speed and interaction design has intertwines with environment experience more and more, it is necessary to discuss the constraints of Interactive Environment Design (IED). In this work, we present an integrated framework to create desirable IED for public use considering both internal parties and external stakeholders. Specifically, we analyze three types of constraints related to IED including management constraints, input constraints and system constraints. The proposed framework is investigated through the case study of Shek Kip Mei IED project for public use in Hong Kong. It could be used as a reference for academic research and industry practice in the future.

Keywords

Interactive environment design, Constraints, Variables

Introduction

In this paper, constraints are firstly explained and defined based on existing literature. It is followed by reasoning argument of the use of constraints in process of interaction design, and environment design. This provides foundation upon which the framework of IED constraints is established. The framework could be utilized to describe and analyze constraints systematically. The essential components of the framework like internal and external parties, three categorization of constraints in IED and the fixed and free variables are discussed. After that, it was applied in the case of Shek Kip Mei IED project, which was tracked during whole process from briefing to the opening. The findings of the case of constraints are analyzed finally.

1.1 Definition of Design Constraints

Design constraint is a prerequisite as it explicitly define the boundary of expert knowledge to be included in the design flow (Jerke & Lienig, 2009). It is a rule that influence form through design process and a target that must be met for the design to be successful (Ralph & Wand, 2009) Establishing constraints that based on the exploration of alternative solutions are very important when designers attend to solve formal problems (Wojtowicz, 1986). Although experienced designers know well the boundary that limits design problem, others may feel manually accounting for such heterogeneous a challenge if the design process is not accurately managed. This may be the consequence of disregard of regulation, misunderstanding between team members, or ignorance of routine. Therefore, in different disciplines of design, scholars and practitioners investigate how design constraints attribute to solution through design process. As a bound on an acceptable solution, constraints could be summarized into two kinds according to Suh Nam (1990). One is the input constraints with design specifications, while the other is system constraints that imposed by the system in which the design solution must function.

1.2 Constraints of Environment Design

Architecture, interior, and environment design could be categorized in the input constraints (Eggink, 2000； Arvin & House, 2002; Marson & Musse, 2010; Merrell et al., 2011). Vitruvius (2008) characterizes three manageable specifications of environment design, like commodity, firmness and delight. Robert Venturi (1966) and Christopher Alexander (1964) stated as technology and modern methods advances, the practice and approach of environment design must be changed. Nuanced problems individually with sub-parameters needed to be embraced in the complex and contradictory natures of environment design (Venturi, 1966). Alexander (1964) went one step further by recommending a method of breaking apart a design problem into manageable parameters as a way to best insure that the demands a context has upon the form set within it is met. The origins of parameters may come from a variety of sources like given by a client as a program, an aesthetic preference, safety codes, material properties and so forth.

1.3 Constraints of Interaction Design

Constraints in interaction design are more viewed as system constraints in literature (Randell, 2000; Jackson, 2001; Chittaro, 2010). The design parameters defined in system constraints could be key variables (parameters) that characterize the physical entity created by the design process to fulfill the functional requirements (Freuer et al., 2008). The key variables could be a set of either free or fixed parameters, which compose the system in different levels. A relation between independent variables represents a simple constraint. Relations between dependent variables that mapped into combinations of simple constraints represent complex constraint (Eggink, 2000).

The variables could be the requirement of systems form, fit or function, technology to be used, materials to be incorporated, time taken to develop the system, overall budget, and so on.

Although input constraints and system constrains may vary in one way or another, they share similarity that both of them are cumulated by parameters (variables) and sub-parameters. The IED collaborates both input constraints and system constraints as it concerns design and functional specifications in the flow.

2.1 Constraints of Interactive Environment Design

IED prevails in recent years as technology develops at certain extend that enables the user-environment interaction embedded in real environment. Microsoft sets up its interactive Briefing Center in Switzerland to launch its new product. A business-to-business trade show, the Gum Façade enables visitors to experience products by interactive wall. Center for Children's Literature holds an educational project with the theme of Balder's Funeral Pyre to encourage engagement between children and environment through corridor of flame and other scenarios. Silence and Whispers in Suomenlinna, a UNESCO world heritage site in Helsinki uses place-specific storytelling technology by audio fragments distributed in cave. The project of Aarhus by Light in a concert hall and public park applies media façade to facilitate playful and social interaction.

Because of the highly applicable and collaborative nature, interactive environment is difficult to study from a singular perspective. Even given the complexity of IED, the range of viable solutions to a design problem remains wide. The use of constraints can be a method of way-finding in the design process. This could be accomplished previously by forcing designers to explicitly state a problem in checklist. However, the design process involves experts from more than one discipline. Thus, it is necessary to delimit the constraints of IED from a systematic manner.

Possible design parameter composed of IED constraints could be uniformly represented in an abstract form agreed by internal and external parties. This act allows design alternatives to be generated and evaluated fast by demonstration of the attributes to the solution for criticize and revision (Eggink, 2000). The fail of doing so will be a hindrance to a cost-effective, user-centered and functional-excellent environment. Under this circumstance, a framework for IED with a set of free or fixed parameters, which facilitate to focus the scope of design by narrowing the range forms and the relationship.

2.2 Framework of Interactive Environment Design Constraints

Complications may arise during the design process mainly due to two points: different decisions from different parties, externally and internally; categories of constraints such as the management constraints from client and inspector, input constraints of environment design, the system constraints of interaction design. The following

session will discuss the details of these two points under the framework of IED constraints.

2.2.1 External Parties & Internal Parties

In the Fig.1 below, the four circles represent four involved parties in the framework. The arrows represent constraints that exert on each other. The external parties of client and inspector include government, media, scholars, social organizations, and relevant professionals. In regard of the nature of IED for public, most of these projects are initiated and inspected by government in Hong Kong, reported by media, suggested by scholars and supported by social organizations. Relevant professionals serve as consultants for these projects. For example, the knowledge of architecture, construction, and engineering experts from Arup and Ronald Lu & Partners provided consulting service to the interactive museum of Hong Kong Zero Carbon Building. As IED has been studied based on user specified requirements, target user like general public, citizens, especially children, young and elder who usually are main visitors could be considered as external parties. Their ideas, requests, interests and behavior could be valued to study and apply in design.

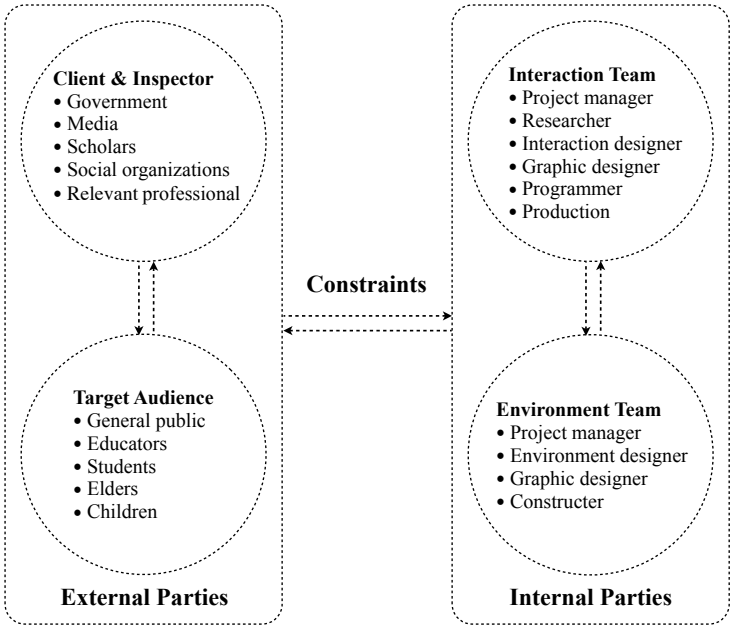

Fig 1. Internal and External Parties of IED for public (by author)

It is important to negotiate with internal party to maintain integrity in design, because IED requires seamless collaboration to create consistent user experience. The team members are people from various disciplines and backgrounds, including human factors, IT, graphic design, multi-media design, interaction design, environment design, research, documentation, and project management. While team members bring different areas of expertise to the project, they may have distinct agendas, opinions, or argument to the same questions. For example, if environment design team didn't consider the technological limitations of interaction technology, such as

projector performs less satisfactory in strong lighting area. They may accidently locate the projector where expose to daylight.

It is very hard for internal and external members always reach a consensus, and work towards a shared vision. For example, there could be this situation that government officers are too persistent to their own preference and neglect experts' suggestions. Or designers aim to sell lofty design in regardless of the practical constraints like budget and time. Misunderstanding, miscommunication, and misinterpretation may impede concepts to be generated into solutions in initial stage and solutions to be implemented in further progress. This could happen in each stage. So whenever internal and external parties encounter with disagreement, they should resolve clearly, and enforce their decisions in order to reduce implementation error and costly revisions. Based on the two parties, three separate categories of constraints in the framework are established and explained in the following session.

2.2.2 Categories of Constraints in IED

Constraints could happen between design variables on different abstraction levels internally and externally (Freuer et al., 2008). All of these variables exert by or on internal and external parties are important to include in the framework in order to comprise the entire design process.

2.2.2. 1 Management Constraints

Debra Herschmann (1995) stated that in management constraints, theme, budget, time, government codes, regulations would be fixed variables that didn't changed so much. Because accuracy estimating and explaining these information at the early stage of project will help design teams to understand what goal is expected to accomplish. Government and project managers need to accurately predict and estimate the problem to implement it. They need to define the best implementable solution, prepare with alternatives, and pursue primary estimation. Besides variables mentioned above, the constraints like sustainability, environmental impact, acoustic calculation, low maintenance cost, reliable and durable, positive influence could also be raised in tender, briefing session or meeting discussion.

When the project progress, continual revision of the project happened based on changing budgets and re-estimations. According to the revision, schedules may be adjusted to coordinate with internal teams and external parties. Way to collaborate may change in different stages internally and externally. For example, at initiate stage, researcher may take the lead of studying, gathering and synthesizing solid information from observation, interview, and focus group, while in later stage environment designers may plan the function and theme of different areas together with interaction designer.

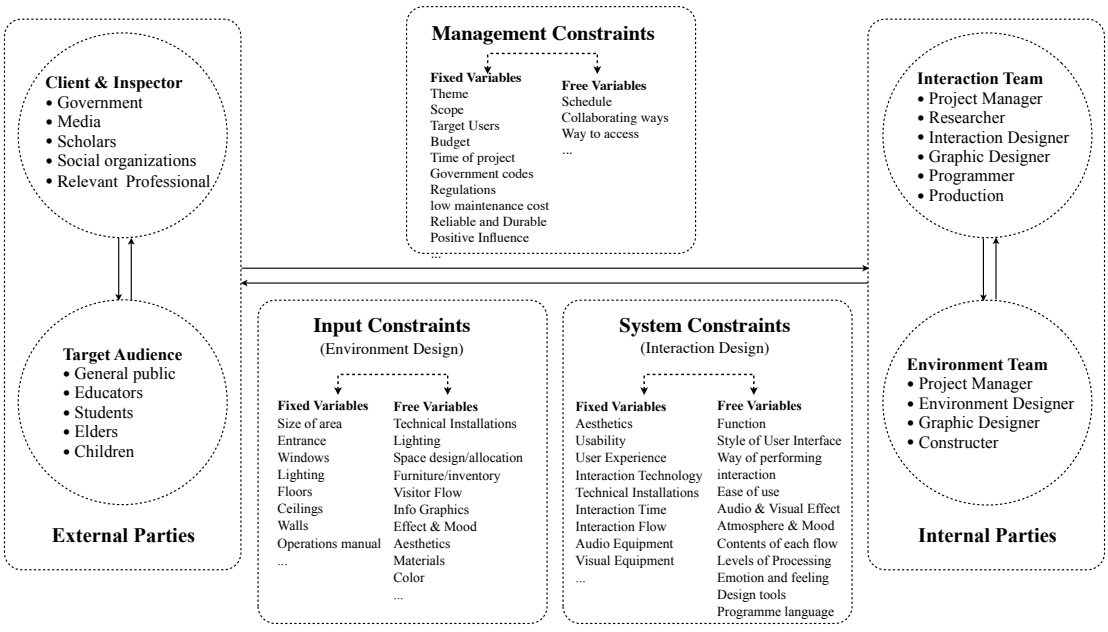

Figure 2. Constraints of IED contributed by Internal and External Parties (by author)

2.2.2.2 Input Constraints

With regard to the input constraints, Berman and Evans (1995) and Turley and Milliman (2000)'s theory are taken as foundation for the framework. The variables included in their works demonstrate a user-oriented perspective, in the sense that many of the fixed variables are typically out of designers' control, such as size of space, entrance direction, location of windows, materials of floor, height of ceiling and walls. Bounded by these restrictions, designers could work according to their own agenda. Compared with fixed variables, free parameters allow designers more freedom. They can select how to install technical equipment, rearrange the light, segment space, fulfill it with new meaning, select furniture; design the visitor flow; integrate information graphics on the wall and floor; create effect and mood to the space; enhance aesthetics and style; select materials and color of interior.

The IED for public is usually designed in this sequence: segment the area into several zones according to the constraints of contents and design scope. For example, the scope is to design a leisure interactive environment with 500 square meters for public to relax and enjoy art pieces. At the beginning of the design process, designers define the fixed variables like the size of space of 500 square meters; the scope is to design a leisure environment; the target user is public. After several meetings with different parties, they collaborate internally and externally to decide a certain type of planning and designing, like how many themes to be included, where should they be, how to segment the space according to the themes, how to manifest these themes in design, what interior style should take, what kind of interaction experience could the space facilitate, and so on. Further more, the interaction design should correspond with the atmosphere created by the environment design.

2.2.2.3 System Constraints

In regard of system constraints, early studies of Kurasu and Kashimura (1995) offered intriguing findings regarding positive roles of aesthetics and usability on system design. Further studies by Thuring and Mahlke (2007) demonstrated that other variables like the technology selected, time and flow of interaction also meditate the attitude and emotions of users towards the system. In a recent survey of the user experience (UX) literature, Bargas-Avila and Hornbaek (2011) found that emotions, enjoyment and aesthetics are the most frequently assessed dimensions of UX. These variables are fixed ones in the way that they could not be compromised even given the management constraints. The system could not be displayed obnoxiously, difficult to access, emotional disgusting, too long or too confused to play, which may lead to horrible experience and failure of the project.

Based on these fixed variables, designers could articulate the concept of UX with various free choices. According to the fixed theme, psychology and behavior of target visitors, designers can define how the interaction system operate, what functions it carries out. Functionality that is not critical or can easily be incorporated in later release could be eliminated. Alternative recommends, less costly functions need to be estimated in knowledge base if the original one didn't work. Besides, designers must frequently remind themselves of usability and affordability when collaborate with expert programmers, because programmer's awareness will result in more user-friendly and stable system with less bugs and cost per feature. Other free variables are also needed to be considered like different way of performing interaction; what language is used to write the programme; what tools to design the user interface; what contents of each flow are; what audio & visual effects are, what kind of atmosphere & mood the space creates; what emotion and feeling the users get; how to facilitate users to interact with system; how many levels of processing, and so on.

The framework investigated composes of management constraints, input constraints and system constraints. Although the variables listed could not represent all the possibilities, they demonstrate how the framework operates and what kind of variables could be included. This framework is further elaborated by the project of Shek Kip Mei Interactive Environment Design Project designed and constructed in Hong Kong in the following session. Management constraints, input constraints, and system constraints were all took into account in order to investigate they correspond with each other in a dynamic design process.

3. Case Study of Skek Kip Mei Interactive Environment Design Project

The Housing Authority (HA) of Hong Kong initiated to build a public space in Mei Ho House. This project was named the Shek Kip Mei Interactive Environment Design (SKMIED). The project was meaningful and memorable as Mei Ho House belonged to the first public housing programme launched in 1953 and also the last remaining example of the "Mark II" single-block configuration in Hong Kong (Choi, 1975). However, as 50 years passed by, young people gradually moved out of this district leaving only old generations behind. The district is facing the destiny of reconstruction. As Mei Ho House served as an historic landmark symbolizing the history of Hong

Kong, HA proposed to transform it into a city hostel and set up an educational and memorial interactive space for public.

3.2 External and Internal Parties for SKMIED

External parties for SKMIED included officers of HA, scholars of Hong Kong history and architecture, social organizations of arts and exhibition, inhabitants of Shek Kip Mei, general public in Hong Kong and so on. The main target users were elders, youth, children and travelers. The design team consisted of a core of designers with a range of environment, user interface and programme design experience. One project leader was responsible for resource management, scheduling and negotiation internally and externally. A design researcher, a graphic designer, a programmer, a space designer, and a team of constructers comprised the other positions of internal parties. This multidisciplinary approach encouraged discussion and allowed diversified perspectives and expertise to be incorporated into the SKMIED project.

3.3 Management Constraints of SKMIED

The whole project lasted for three years, while the interactive environment design project lasted for about one year from the first briefing to the openness. However, the original schedule for SKMIED was half year, as the rebuilding construction was postponed, it could not meet the expected deadline, which led to the delay of the SKMIED project. In this way the fixed variables of time and budget changed to free variables. And free variable of schedule was revised accordingly. Other fixed variables like the scope, government codes, regulations, low maintenance cost, reliable and durable, positive influence remained the same. For example, at the beginning of the project, the design team had attended the major meeting that between officers of HA and the rebuilding constructors. All of the regulations such as the Redevelopment of Shek Kip Mei Estate Phase II and Phase V and building specifications were understood and followed. Thus the design and implementation of this project were under boundaries of management constraints.

3.4 Input and System Constraints of SKMIED

The area totaled around 500 square meters with two floors, each 250 square meters. It had six entrances on the ground floor and ten entrances on the first floor accessing to the main area. On these two floors, twenty-four fixed existing structural walls were used to segment different apartment for living in the old time. The area enjoyed half daylight and half lighting system hung from the ceilings. After construction, the floor was covered with dust proof hardener and paved with mosaic tile and heavy dust anti-static carpet tile. These fixed variables built the foundation upon which environment designer was required to adhere to.

Before the environment and interaction design, research was conducted to gather historical evidence like books, photos, documentaries, which generate contents of SKMIED including information, knowledge, data and facts. Based on the structure of contents, the area was divided into several categories, however the condition of site

was quite a different story (Fig 3). As the existing walls circulated fourteen zones naturally, designers needed to compromise between the intended plan, the site condition as well as the user experience. After the fierce discussion between external and internal parties, agreement was reached and the area was divided into nineteen zones with different themes and functions of each one. The zones as free variables decided in the input constraints were later applied as fixed variables in system constraints. Although the fixed wall supporting building structure could not be moved or demolished, twenty-eight new lightweight block walls were designed as partition in both floors. The free variables of whole interactive environment experience, visitor flow, location of interactive technology, aesthetics standards like style, color, materials and mood were considered by interaction designer and environment designer together and set as fixed variables for later stages.

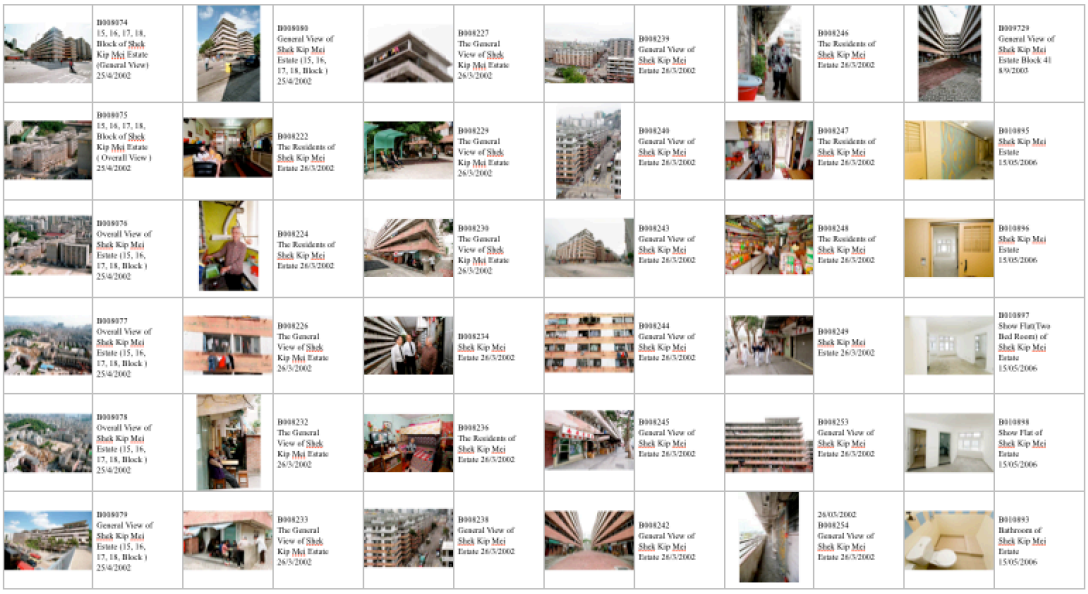

Fig 3. Part of photo documentation of Shek Kip Mei Estate

Base on the consensus achieved in previous stage which turned into fixed variables for interaction design, designers and programmer collaborated under these boundaries to simulate the scenario of user experience with selected interactive facilities for SKMIED. At the same time, designers imbedded the interaction scenario, into environment design including the storyline of the contents, style, mood, reference examples in a presentable way for better discussion among parties. For example, one of the zone was called My Life in Shek Kip Mei. It employed characters of the inhabitants in the Mei Ho House in old times, like little girl, grandma, friends of neighborhood, father and mother, police officer and firefighter. The interaction system played the daily life they lived and encouraged visitors to interact with them by gesture control system (Photo 1). This proposal served as the first prototype of the overall design synthesizing IED.

Photo 1. Interaction system in the zone of My Life in Shek Kip Mei

Besides the proposal, the technical list specification included wall projection, floor projection, and 360-degree projection with or without gesture control, touch screen, display screen, and augmented reality technology was proposed for discussion. Internal and external parties negotiated based on management constraints of cost, budget, time required, performance, capability, durability, and energy consumption. When the interaction facilities were selected, designers and programmers revised the scenario abandoned or added features required. This stage could be back and forth for several times, until both parties reached balance. When the outline of user experience was confirmed, the detailed design of each facility like time, flow, contents, interface, functions, language, audio and visual effects were designed and reviewed.

Although the environment design and interaction design were operated separately as two domains, in the SKMIED case, two teams endeavor to synchronize the paves as if it was developed by a single people, not by a variety of designers and programmers with varying skill level and design styles.

Discussion

When the framework was applied in SKMIED project, an interesting phenomenon was raised that variables could transform from fixed to free or vice versa. Two conditions appeared with the consequence of transformation. One was that free variables in primary stage changed into fixed in later stage. For example, the location of technical facility was a free variable in the process of environment design at first. But after confirmation, it became fixed variable in the process of interaction design. This change related to which stage was sequentially and strategically superior to other stages, even if the sequence might vary in different projects. In perfect status, all

decisions were rigorously considered and irreversibly enforced. However, in real world, there is this chance that fixed variables determined in previous stage could change back to free variables later. This is a chance that the project may exceed the management constraints of time and budget after several revisions. Or alternative plan was required to replace the original. It was common that the final achievement was generated from continuous breakup and reconstruct process until agreement was approached among different parties.

The advantage of the framework is that it provides different parties a platform upon which to discuss and collaborate. It reminds participants to check all the linkage between internal and external efforts to assure the positive progress of the project. As the project requires continuous adjustment, if the variables in the framework weren't changed accordingly, it could start a chain of negative reaction or even lead to financial disaster or failure of the project. It might jeopardize all the efforts that internal and external parties made. The dynamic view of the variables to decide which could be revised and which could not to be requires management experience, judgment and negotiation skills. As the regulation, routines, and management styles in different regions and countries are different, the framework needs to be included and excluded certain variables in order to be localized for specific needs.

Conclusion

The IED design process is essentially a continual evolving process involves coordination of internal and external parties. It consists of a great range of indistinct and context-dependent constraints in the fields of management, input and constraints with fix and free variables. Considering the factors above, the paper presents a framework about the constraints of IED, which was applied in the case of SKMIED project. Through the project, we discovered that the characteristic of variables might alter in different stages naturally or artificially, given the stages of different project may differ. This phenomenon might exert an important influence on the result of the project. Further studies will be conducted to evaluate the framework by other cases.

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