Conceptual Analysis of the Digital Innovation Hub as a Value Delivery System

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Abstract. *This paper explores the conformance of the concepts underlying the Digital Innovation Hub (DIH) with the concepts of value delivery systems. DIH literature was used as a DIH source of information and Object Management Group's (OMG) specifications were used for creating a metamodeling framework. The basis for the analysis is metamodeling, with the basic metamodel being Value Delivery metamodel of the Value Delivery Modeling Language (VDML). The research hypothesis is that DIH business model is delivery of value, which was tested by the conformity of the generic DIH metamodel (DIH RMM) with the VD metamodel. Further study is suggested.*

Keywords. Digital Transformation, Digital Innovation Hub, Value Delivery System, VDML, Metamodeling, Conceptual Mapping

1 Introduction

Digital transformation (DT) dramatically changes the way business was done in the past, introduces the whole new way of thinking and living, allows seamless work, and introduces new models and organizational structures. The technologies which are recognized as the ones having the highest impact on DT are High performance Computing, Internet of Things, Block-Chain, Robotics and Artificial Intelligence, but European Union (EU) Member States (MS) are not exploiting them enough, whilst the intensity of DT paints a very heterogeneous landscape within EU (European Commission, 2019a).

DIH is one of those organisational structures introduced in order to make the DT possible and more widely applicable. They were first introduced in 2016, as one of the priorities of utmost importance in Digitising European Industry Initiative, based on the notion that the level of digitalisation amongst EU MS should be more homogenous, that it is more than necessary for enhancing EU's competitiveness on international market, and that only one fifth of EU's small and medium-sized companies (SMEs) is highly digitalised (European Commission, 2019a). That ratio is very concerning, especially taking into account that SMEs carry out 99% of EU businesses (European Commission, n.d. a). In that regard, DIH is a policy instrument, making much needed DT support readily available (Rissola & Sorvik, 2018).

The aim of this article is to provide insight in DT related novel organizational structure called DIH and its added value, mapped onto a VDML metamodel, in order to explore its suitability for DIH reference metamodel (RMM DIH), which can in future be used as a benchmark for DIHs.

After the introduction, this article is structured in a way that it first explains the concept of DIH and refers to the relevant sources of information regarding it. Then it explains concepts regarding Value Delivery Systems and VDML with a special view of VDML metamodel. Following that, research methodology is explained and then conformance analysis is conducted through conceptual mapping of DIH concepts onto VDML classes. The conclusion also suggests further research.

2 DIH Concept and Reference Sources of Information

DIHs can help companies, regardless of their size, digitalise their businesses, providing a wide spectrum of one-stop-shop services, whilst heavily relying on knowledge and technology transfer provided by

technical universities or research establishments at their very core, which is illustrated on Fig. 1 below (European Commission, 2019a). They should be the very first regional points of contact when it comes to existing industries' demand-side endeavours regarding DT, which is what distinguishes them from clusters (Miörner, Kalpaka, Sorvik, & Wernberg, 2019a).

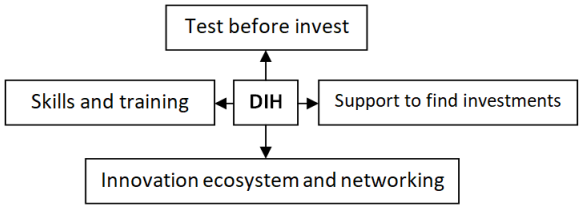

Figure 1. Digital Innovation Hub mission, Source: Adjusted from European Commission (European Commission, 2019a)

When it comes to being the first point of contact, it is worth mentioning that proximity also plays an important role. One study shows that geographically isolated locations with little population find it difficult to attract highly skilled and talented workforce (Lantz & Wu, 2017). The authors also mention possible solutions but they do however require additional investments, which often less isolated and more populated regions don't have to endure. It is also important to emphasize that DIH value proposition should be based on established needs of the industry, and then formed into a unique offer (WG1, 2017).

DIHELP guide for Applicants states that DIHs offer the following services to their users: "access to digital technologies and competences, infrastructure and training to test digital innovations, financing advice, market intelligence, networking opportunities, access to digital skills development and training" (European Commission, 2019b, pp. 2-3). That list is not exhaustive, but highlights the only the basic DIH offerings to its customers.

DIHs bring different stakeholders together, trying to create synergy through mutual engagement of different MS and regional policies created by state governing bodies and European Commission (EC), members of the industry (especially SMEs), academia and research entities. Already existing potential and needs of certain areas should be the starting point in order to support already existing EU industries in their DT endeavours (Rissola & Sorvik, 2018). MS created and adopted Smart Specialisation Strategies (S3) which define priority areas for research and investment taking into account the before mentioned potential, and based on European Cohesion Policy 2014-2020 (Miörner, Rissola, Sörvik, & Wernberg, 2019b). Most existing DIHs today are either existing actors which merely rebranded themselves, existing actors with new focus which involves DT, or entirely new actors (Miörner et al., 2019a). EC has not so far provided detailed criteria for DIHs, (Virkkunen, Still, & Rosso, 2019), which leaves space and an opportunity for further study.

DIH as an intermediary in this comprehensive multi-stakeholder policy aligned collaboration, amongst other things deals with matchmaking through the use of showrooms for local technologies, engaging events, exploiting websites as platforms with different tools, creating networks of suppliers or by promoting different organisations' complementarities (Rissola & Sorvik, 2018). This matchmaking or brokering is also achievable trough: roadshows, workshops, innovation camps, and hackathons (WG1, 2017, p. 12). Multi-sided platform (MSP) approach could also be one way of looking at DIH platform functionalities.

Regarding DIH funding; MS and regions are to invest in their respective DIHs, possibly through European Regional Development Funds (ERDF), and align them with their own digitalisation strategies, whereas EC has been providing 100 mil € every year from 2016 to 2020 to enable pan-European DIH network, in order to compensate for some DIH shortfalls with the resources available elsewhere, creating opportunities for knowledge transfer (European Commission, 2018). DIHs deal with financing challenges in different ways; whilst basic services provided should be free of charge, DIH sustainability is usually achieved through different means such as public funds, membership fees, and commercialising their own more specialised services (Rissola & Sorvik, 2018). One research showed that most DIHs are not financed directly by their S3s, in spite of the fact that they have been aligning their work endeavours with it, and some even helped create it (Miörner et al., 2019b).

DIH sources of information are rather scarce, especially in scientific literature. Therefore, the biggest sources of information regarding DIHs are EC's Joint Research Centre (JRC) technical reports and platforms. Comprehensive list and information on DIHs in Europe can be found in the Digital Innovation Hubs tool, a part of S3 Platform, created as a platform for DIH networking with one another (European Commission, n.d. b). DIH tool contains information on DIHs in EU MS and non-EU states in Europe, and can be used to search the catalogue taking into account also evolutionary stages (in preparation, fully operational or potential DIHs from Horizon 2020 Programme[1]), 25 different technical competences, 15 different services provided, with focus on 8 different Technology Readiness Levels (TRLs), 20 different market sectors, and whether they are involved in H2020 projects (European Commission, 2020). The tool also shows DIH information, on interactive map as well as listed, currently encompassing information on 618 DIHs (European Commission, 2020). DIHNET.EU project, JRC DIH catalogue interactive community, supports

[1] EU Research and Innovation programme, financial instrument

DIH network collaboration across Europe, in order to create added value through sustainable, cooperable and coordinated pan-European network of networks, whilst offering tools and services to DIHs, organising DIH Champions Challenge, and focusing on regional DIHs (TNO, n.d.).

The proposed Digital Europe Programme (DEP) for the upcoming six year period, will focus on creation of EU strategic digital capacities, provision of funds for supercomputing, artificial intelligence, cyber security and advanced digital skills, whilst allowing deployment of digital technologies throughout EU's economy and society, in order to further enhance DT (Commission, 2019c). EC will continue to invest in DIHs, and DEP will provide grants to one DIH per EU region, which will be called European Digital Innovation Hubs (EDIHs) (Virkkunen et al., 2019).

3 Value Delivery Systems, VDML, VDML Metamodel

Conformance of the concepts underlying the DIH is confirmed through the concepts of value delivery systems. The research hypothesis is that DIH business model is delivery of value. This research aims to map DIH, as a value delivery system, onto a VDML metamodel, in order to explore its suitability for RMM DIH.

According to Lanning & Michaels (as cited in Ballantyne, Frow, Varey, & Payne, 2011, p. 203), Value Delivery System (VDS) was first mentioned in scientific literature 1988, and it was comprised of three steps: choose the value, provide the value and communicate the value. VDS aims to deliver as much value as possible to its customers whilst simultaneously creating profit for the participants in the process (Ji, 2008). Some authors also describe projects as VDS and seek for their optimisation (Drevland, 2019).

OMG creates specifications for applications, which implement Model Driven Architecture (MDA), and amongst which also Unified Modeling Language (UML) specification (OMG, 2018). It also provides a specification for VDML for managerial staff, and whose purpose is creation of business design models connecting strategic and operational level of corporate business, in order to enhance common understanding of business transformation (OMG, n.d.). VDML focuses on the value chain, complex collaborations, business networks, activities, roles and capabilities (OMG, 2018). Value modeling can be used to depict both creation and exchange of values (Roelens & Poels, 2013). Meta Object Facility (MOF) is OMG's modeling and metadata specification, part of MDA family of languages, which provides framework for open and platform-independent management, in order to allow creation and interoperability of systems handling models and metadata (OMG, 2019). MOF allows models to be transported from one application to another, stored, retrieved, transformed into different formats, and used for the creation of application code (OMG, n.d.). Metamodel is a model of the model, used for modeling models and arbitrary metadata, with the minimal number of two layers (metalevels) (OMG, 2019).

For the purpose of this research, the methodology displayed at Fig. 2 below is the following: UML Model represents Object of Modeling, and conforms to UML Metamodel (for additional specification); UML Metamodel conforms to MOF (a meta-metamodel setting rules for metamodeling); object of modeling is a DIH system; DIH model representing DIH System is created as an UML model, and it conforms to DIH RMM.

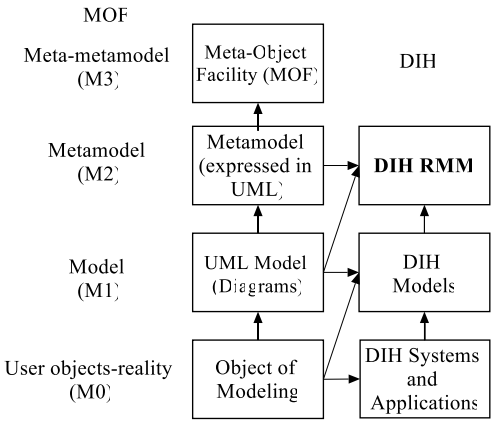

Figure 2: UML, MOF and DIH, Source: Authors' own creation

The next step in this methodology, displayed in Fig. 3 below, is extending the metamodeling by using VDML profile, a UML profile for value delivery (VD) systems. As shown in the figure: VD System (VDS) is an Object of Modeling; VDS Model (VDSM) is an UML profiled model, which conforms to VDML - a Metamodel of VDSM which represents a VDS.

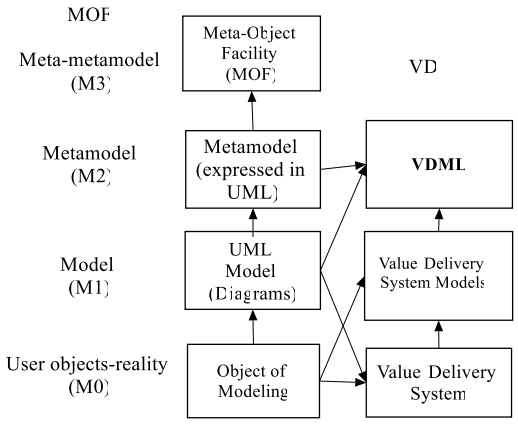

Figure 3: Extending the metamodeling by using VDML profile, Source: Authors' own creation

The complete methodology concepts are depicted in the Fig. 4 below. DIH RMM is what the authors are trying to create and that is, besides the methodology, the scientific contribution of this research. DIH RMM is important because it can be used for DIH benchmarking, comparison of DIHs, and it can also be used as a reference point providing guidance for what a DIH should be comprised of. Also, DIH RMM design can be useful for structuring DIH catalogue.

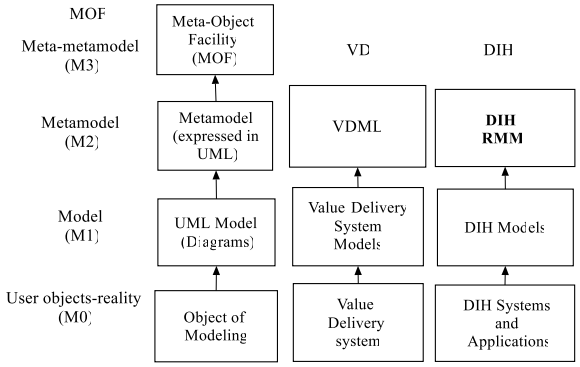

Figure 4: Research methodology concept, Source: Authors' own creation

4 Conformance Analysis

The research is based on the hypothesis that DIH's business model is essentially a delivery of value. We will prove this by proving the conformity of the generic DIH model (DIH RMM) with the VD metamodel (part of the VDML specification), as displayed on Fig. 5 and Fig. 6 below.

Conformance Analysis will be implemented at the level of VDML Collaboration Modeling Conformance; the VDML metamodel subset can be used for structures and relationships in organisation, and it conforms if XMI can be imported and exported consistently with Structured Metrics Metamodel (SMM) and VDML Metamodel Conformance (Subclause 2.2) whilst implementing the following classes: ValueDeliveryModel, VdmlElement, MeasurableElement, Attributes, Annotation, MeasuredCharacteristic, PortContainer, Collaboration, Role, RoleDefinition, RoleLibrary, RoleCategory, Participant, Actor, Person, Assignment, OrgUnit, Position, Community, Member, BusinessNetwork, and Party (OMG, 2018, pp. 3-4). The same source further states that before mentioned conformance level is a subset of VDML Metamodel Conformance (Sub-clause 2.2), but that it does not conform to VDML notation (Sub-clause 8) (OMG, Value Delivery Modeling Language (VDML, 2018).

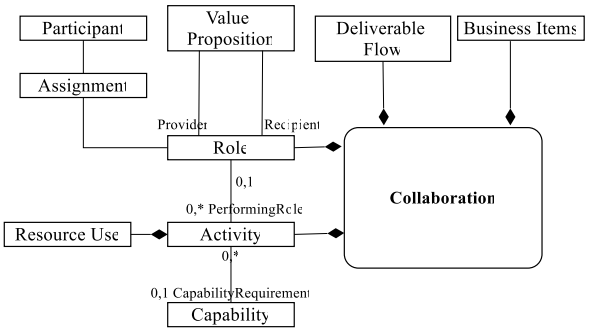

Figure 5: Collaboration sub-model, part of the VDML metamodel, Source: Author's own creation based on OMG VDML Specification (OMG, 2018)

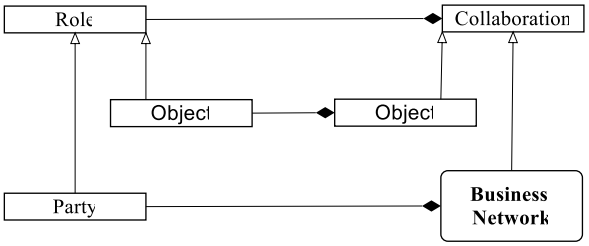

Figure 6: Business Network sub-model, part of the VDML metamodel, Source: Author's own creation based on OMG VDML Specification (OMG, 2018)

VDMbee is a Value Management Platform which monitors business trends and tries to improve them by, amongst other things, maping ideas into perspective of Value Delivery, and describing business models in OMG's Value Management Language (VDMbee, n.d. a). The platform allows insight regarding value creation and delivery, and prototyping business transformation in accordance with Value Objectives (VDMbee, n.d. b). It also uses Value Stream Maps for specification of Value Streams; artefacts which allow specification of value proposition and which are depicted as streams of activities (VDMbee, n.d. c). Value Proposition is also an integral part of Business Model Canvas for which VDMbee can create simulations (VDMbee, n.d. d). Taken into account the usefuleness of the methods offered by VDMbee platform, Value and Value Propostion class is also an important concept for this research.

In order to carry out the analysis, each of these before mentioned concepts should be identified in the selected DIH documents (conceptual mapping). Concept maps graphically represent knowledge in form of concepts and relationships between them, represented hierarchically, with the most general concept at the top, in order to allow meaningful learning (Canas et al., 2003).

In this research, each mapped concept was displayed in a table; the first column of the table is composed of before mentioned VDML classes important for the conformance analysis, and each literature source has one column for the examples of concepts and also a column for comments. Classes

'Value and Value Proposition', 'Activity', as well as 'Resources and Stores' of OMG Specification (OMG, 2018) were also added because they can be used later on for some other methods. Due to extensiveness of the table, only some classes and mapped concepts will be listed in this article. The first row of the table is reserved for ValueDeliveryModel class, which is DIH RMM, and the second row is reserved for VdmlElement class, which is DIH Model.

Following the illustration on Fig. 5, those classes and mapped concepts will be shown first. Collaboration class examples of the mapped concepts are the following: Micro- and small enterprises, Medium-sized enterprises, Mid-caps, Large companies (DIH customers) (Miörner et al., 2019b, p. 21); Regional cluster organisations, Cluster organisations from other regions, Regional government, Chambers of commerce, Trade associations, Enterprise Europé Network (EEN) local..., Innovation support organisations, Incubators, Vocational training organisations, Funding organisations, National government, Investors (Miörner et al.,, 2019b, p. 31); Internal human capital: Internal skills (employed/affiliated), Universities within DIH consortium, Business actors within the DIH, Public actors within the DIH consortium, Business actors within the DIH consortium; External human capital: Other DIHs outside the region, Universities within the region (not part of DIH), Universities outside the region, Business actors within the region (not part of DIH), Business actors outside the region, Business actors within the region (not part of DIH, Public actors outside the region, Public actors within the region (not part of DIH), Other DIHs within the region, and other DIHs outside the region (Miörner et al., 2019b, p. 28).

Role class inherent examples of concepts are the following: Knowledge provider, Technology provider, Knowledge recipient, Technology recipient; Policy creator, Funding recipient; and Infrastructure provider (DIH tangible role) (Miörner et al., 2019b).

After providing the examples of Role class concepts, examples of Community and Member class concepts will be provided, even though they are not shown on the Fig. 5. Examples of Community mapped concepts are the following: Micro- and small enterprises, Medium-sized enterprises, Mid-caps, Large companies (Miörner et al., 2019b, p. 21); Internal human capital: Internal skills (employed/affiliated), Universities within DIH consortium, Business actors within the DIH, Public actors within the DIH consortium, and Business actors within the DIH consortium (Miörner et al., 2019b, p. 28). By researching DIH literature, the inherent conclusion regarding concepts to be mapped in Member class would be for example: Individual employees within DIH enterprise and companies-especially the ones on executive positions making business decisions; Individuals at universities within DIH, and individuals in public bodies within DIH (Miörner et al., 2019b).

The examples of mapped concepts regarding Activity class are the following: educating, internationalisation (Miörner et al., 2019b); training, skill developing, business advising, helping with business plans, supporting scale-up and internationalisation, matching new firms with customers, testing and validating, and attracting funding for financing DIH activities, (Miörner et al.,2019b, p. 18).

For the reasons of brevity, only BusinessNetwork, Collaboration, Role, and Party classes from Fig. 6 concept examples will be listed next.

Examples of BusinessNetwork are the following: Regional cluster organisations, Cluster organisations from other regions, Regional government, Chambers of commerce, Trade associations, Enterprise Europé Network (EEN) local..., Innovation support organisations, Incubators, Vocational training organisations, Funding organisations, National government, Investors (Miörner et al., 2019b, p. 31); External human capital: Other DIHs outside the region, Universities within the region (not part of DIH) Universities outside the region, Business actors within the region (not part of DIH), Business actors outside the region, Business actors within the region (not part of DIH, Public actors outside the region, Public actors within the region (not part of DIH), and Other DIHs within the region, Other DIHs outside the region (Miörner et al., 2019b, p. 28).

Next, examples of mapped concepts of Collaboration are the following: Micro- and small enterprises, Medium-sized enterprises, Mid-caps, Large companies (DIH customers) (Miörner et al., 2019b, p. 21); Regional cluster organisations, Cluster organisations from other regions, Regional government, Chambers of commerce, Trade associations, Enterprise Europé Network (EEN) local..., Innovation support organisations, Incubators, Vocational training organisations, Funding organisations, National government, Investors (Miörner et al., 2019b, p. 31); Internal human capital- Internal skills (employed/affiliated), Universities within DIH consortium, Business actors within the DIH, Public actors within the DIH consortium, Business actors within the DIH consortium; External human capital- Other DIHs outside the region, Universities within the region (not part of DIH) Universities outside the region, Business actors within the region (not part of DIH), Business actors outside the region, Business actors within the region (not part of DIH, Public actors outside the region, Public actors within the region (not part of DIH), Other DIHs within the region, and Other DIHs outside the region (Miörner et al., 2019b, p. 28).

Role class mapped concepts inherent examples are the following: Knowledge/technology provider, Knowledge/technology recipient; Policy creator, Funding recipient, and Infrastructure provider (DIH tangible role) (Miörner et al., 2019b).

By researching DIH literature, the inherent conclusion regarding concepts to be mapped in Party class are the following: Regional Clusters, Governments, Chambers of Commerce, Trade Associations, Members of Enterprise Europé Network (EEN), Innovation support organisations, Incubators, Vocational training organisations, Funding organisations, Investors; other DIHs, Universities not in DIH, Business actors not in DIH, and Public actors not in DIH (Miörner et al., 2019b).

Last but not least, example of mapped concepts of Value and Value Proposition class is Technology transfer (Miörner et al., 2019b). Due to the extensiveness of the table created for conceptual mapping, only a part of it is shown in the Table 1 below.

Table 1: Conceptual mapping of DIH concepts onto VDML classes, Source: Authors' own creation

VDML concepts	Lit source 1	Lit source 1 comments
Participant	For example in a DIH or project: SMEs from region, Regional Incubators, Partners	- *whatever fills a role in collaboration (OMG, 2018)*
Actor	For example in a DIH or project: E-elarning platform, Project Manager, Communication Officer, Partners' points of contact, Library (database)	- *human or non-human participant (OMG, 2018)*
Person	For example in a DIH or project: Project Manager (specific person), Communication Officer (specific person), all the partners' points of contact (specific persons)	
Assignment	For example in a DIH or project: Meeting participation, Webinar participation	- *participant performs Activity through Assignment, which specifies how a Role is filled in collaboration (OMG, 2018)*
Value and Value Proposition	TT (Miörner et al., 2019)	

5 Conclusion

This article provided some insight in DT related novel organizational structure called DIH and its added value, mapped onto a VDML metamodel, in order to explore its suitability for RMM DIH, which can later on be used as a DIH benchmark, for DIH comparison, but also as a blueprint for information system architecture design.

Researchers used UML Model to represent Object of Modeling, which conforms to UML Metamodel; UML Metamodel conforms to MOF; object of modeling was a DIH system; DIH model representing DIH System was created as an UML model, and it conforms to DIH RMM; metamodeling was then extended by using VDML profile; VDS was an Object of Modeling; and VDSM is an UML profiled model, which conforms to VDML.

Conformance Analysis was implemented at the level of VDML Collaboration Modeling Conformance. In order to carry out the analysis, each of these concepts was identified in the selected DIH documents by performing conceptual mapping. Each mapped concept was displayed in a table; the first column of the table is composed of before mentioned VDML classes, and each literature source has one column for the examples of concepts and also a column for comments. Classes Value and Value Proposition, Activity, as well as Resources and Stores of OMG Specification (OMG, 2018) were also added because they can be used later on for some other methods. Degree of conformance is important for interoperability and systematisation of DIH catalogue.

The researches have established that it is possible to design DIH RMM, as a referent model of a value delivery system. The scientific contribution of this research is the methodology and increased knowledge about DIH, proposed design of VDML DIH metamodel as a value-producing system, and the proposal design of RMM DIH. The societal contribution is the possibility of practical use of the proposed VDML DIH metamodel as a conceptual framework for DIH modeling, and RMM DIH use was already explained. The research is valuable for enhancing synergy between different sectors, in order to contribute to the strengthening of national and also European economy.

Further research should be performed to add more detail to DIH RMM through additional DIH literature research and in-depth interview with DIH expert. The incompatibilities of concepts trough DIH literature review should be noted and the conclusion weather the incompatibilities' analysis provides foundation for the extension of the model should be made. Methodology for validating the model should also be established.

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