Broadband business for new entrants
A techno-economic analysis for utility based firms

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***Abstract* — This study provides a model for analyzing the new perspectives for investors in the broadband business field. It integrates real options, SWOT analysis and fuzzy logic into a decision analysis framework for formulating and evaluating such business opportunities. Finally, we discuss a real case study in the specific business field showing how the model can be formulated and solved.**

Keywords: Broadband communications, Business model, Fiber optics networks, Telecommunications, Real options, SWOT analysis, Fuzzy logic.

I. INTRODUCTION

In the new era of the telecommunications business field the Information and Communication Technologies (ICT) service providers should seek access network solutions with even more bandwidth. The most viable solution for high bandwidth provision, especially in access networks, is the optical fibers technology. Hence, the installation of the optical fibers and their commercial exploitation is a very challenging business activity. Authorities that own physical infrastructure such as service utility companies experience competitive advantage against typical telecommunications operators. These advantages are mainly coming from the lower installation and implementation costs of the optical fibers networks. The potential business investors in the broadband technology field face the dilemma of selecting the optimum development strategy for their investment. In addition, facility-based firms experience lack of specific business experience and because of this they should look for possible joint ventures with telecommunication companies and set up specific subsidiaries for this purpose. In this paper, we propose a decision analysis framework for analyzing and evaluating broadband business opportunities using real options (ROs). ROs were already applied in the ICT field [4][5][13]. Also, options analysis in broadband business field and especially concerning broadband technologies upgrade from ADSL (Asymmetric Digital Subscriber Loop) to VDSL (Very High Data Rate Subscriber Loop), was examined in [10][11][12][15]. For a survey of options theory applications in the ICT field, the interested reader is referred to [7]. We extend the aforementioned works by introducing ROs, fuzzy logic (FL), SWOT analysis in one decision analysis framework. Particularly, we introduce the following:

- SWOT analysis for defining and analyzing the business critical factors.
- ROs thinking for mitigating risks and maximizing performance.
- FL for handling the vagueness of business related information such as customers demand, revenues and costs.

It is the first time to our knowledge, in the literature, where SWOT analysis, ROs, FL are integrated in a common decision analysis framework. Each method complements the other. Particularly, one method alone will be insufficient to address all the decision aspects. It is therefore essential that a combination of methods should be adopted to ensure that there are no gaps. Finally, we apply the proposed analysis to a real world broadband business case to show how it can be formulated and solved. The paper is organized as follows. Section 2 describes the model and the proposed analysis. Section 3 discusses a real world case study. Finally, section 4 concludes and presents a few suggestions for future research.

II. RESEARCH METHODOLOGY AND MODEL

The research goal is to recognize business opportunities for utility based firms, analyze and recognize existing or embedded ROs and finally estimate the overall business value. Figure 1 describes the proposed methodology. Analytically, step one defines the business to be analyzed. In step two, the SWOT analysis is performed for recognizing the overall external and internal business characteristics involved in the specific business field for a utility company. In step three, the financial model of the analysis is set up. In step four, the RO analysis is applied for recognizing existing or designing options for controlling specific risks, threats and exploiting the resulting opportunities. In step five the FL is applied developing a compound ROs model. Finally, in step six the overall business value is estimated.

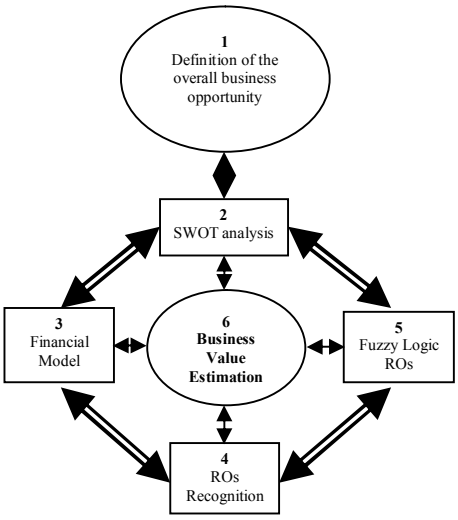

Fig. 1. Research model and methodology

A. Business opportunity for facility-based firms

We focus on facility-based firms, normally utility companies that own a number of physical resources. Such resources may be transportation networks, sewerage and water pipes, electrical wires poles and pylons. Based on this infrastructure, its legal owner may install dark optical fiber for implementing a passive optical network. The activation of passive network (light the fiber) will be the next business stage initiated by the utility firm itself or by a telecommunications company that has the required

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experience. Finally, after the activation of the optical fiber network, the specific services provision comprises the third stage of the overall business.

We assume that the parent utility firm sets up a subsidiary company named NewTelco Services for both entering the telecommunications business as a wholesale infrastructure provider and developing retail fiber access-based telecommunications services. NewTelco Services may undertake the roles NetCo and OpCo. In the first case (NetCo) NewTelco builds and owns the telecommunications access infrastructure, while in the second case (Opco) it activates and operates the active network, figure 2.

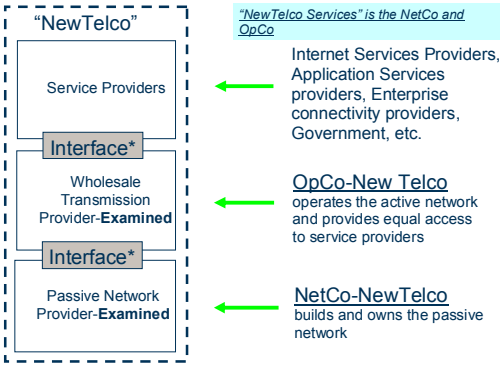

Fig. 2. Business model for NewTelco Services activities

The overall broadband business opportunities for transportation utility-based firms which are willing to act in this field were discussed in [13] and [5]. A wider presentation of business opportunity for utility based firms is given by Angelou and Economides [2].

B. *SWOT analysis*

SWOT Analysis is a strategic planning method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a project or in a business venture. It involves the activities of specifying the objective of the business venture or project and identifying the internal and external factors that are favourable and unfavourable to achieve that objective.

SWOT analysis groups key pieces of information into two main categories:

- Internal factors – The strengths and weaknesses internal to the organization.
- External factors – The opportunities and threats presented by the external environment to the organization.

The internal factors may be viewed as strengths or weaknesses depending upon their impact on the organization's objectives. The external factors may include macroeconomic matters, technological change, legislation, and socio-cultural changes, as well as changes in the marketplace or competitive position. The results are often presented in the form of a matrix.

C. *Financial Model*

The techno-economic analysis of telecommunications business includes demand forecasting for the product (services) examined, the dimensioning of the passive and active parts of the network designed to serve the expected demand, cost and revenue estimation. Finally, the net present value (NPV) and the expanded NPV (ENPV) under fuzzy logic analysis are estimated. The proposed financial model is presented in figure 3.

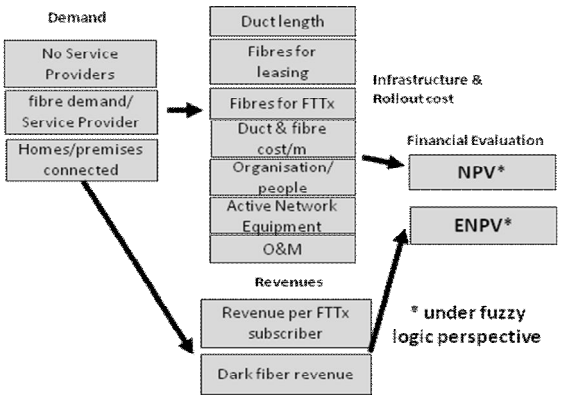

Fig. 3. Financial model

D. *Real options*

An option gives its holder the right, but not the obligation to buy (call option) or sell (put option) an underlying asset in the future at a predetermined price. Financial options are options on financial assets (e.g. an option to buy 100 shares of Siemens at 100€ per share on January 2012). The ROs approach is the extension of the options' concept to real assets. An investment embeds a RO when it offers to the management the opportunity to take some future action (such as abandoning, deferring or expanding the project) in response to events occurring within the firm and its business environment [17]. The amount of money spent for investment corresponds to the option's (to defer, expand) exercise price (X). The present value of the project's asset (total gain of investment) corresponds to the stock price (V). The length of time the company can defer the investment decision without losing the opportunity corresponds to the option's time to expiration (T). The uncertainty about the future value of the project's cash flows (the risk of the project) corresponds to the standard deviation of returns on the stock (σ) for the financial options. However, for real options, we need the volatility of the investment's cash flows. In general, the stock (σ) corresponds to the variation in the cost and revenues cash flows of the investment. Finally, the time value of money is given in both cases by the risk-free rate of return (r_f). The total value of a project that contains one or more options is given by [17]:

$$\text{Expanded (Strategic) NPV} = \text{Static (Passive) NPV} + \text{Value of Options from Active Management} \quad (1)$$

The flexibility value named as option premium is the difference between the NPV value of the project as estimated by the Static or Passive Net Present Value (PNPV) method and the Strategic or Expanded NPV (ENPV) value estimated by the Real Options method. The higher the level of uncertainty, the higher the option value because the flexibility allows for gains in the upside and minimizes the downside potential. Alleman [1] showed how ROs can be helpful to the telecommunications industry for issues related to strategic evaluation, estimation and cost modeling. Examples of ROs applications in

telecommunications investments and particularly mobile networks and broadband technology are given by [13] and [14]. Broadband investments experience a number of risks, which are coming from the internal and external environment of the firm. The uncertainty control or "clearness", achieved by the ROs, is quantified by the volatility of the stochastic parameters such as investment revenues and investment cost [16][17]. Thus the identification of the ROs inherent in a strategy could be driven by the identification of those uncertainties towards which a reaction is possible [16][17]. Strategic framework such as SWOT can provide valuable assistance in identifying low uncertainties (strength), high uncertainty (weakness), upside potential (opportunities), and downside risks (threats) [9].

E. Fuzzy logic and ROs

Most of the decision making in the physical world takes place in a situation in the pertinent data and the sequences of possible actions are not precisely known. Therefore, it is more realistic to adopt fuzzy data to express such situations in decision-making problems. The imprecision we encounter when judging or estimating future ICT investment cash flows is not only stochastic in nature, since the uncertainty may be genuine, i.e. we simply do not know the exact levels of present value of the expected future cash flows. We model this vagueness for the aforementioned investment parameters by adopting fuzzy logic analysis. We model the expected values for one time investment cost WaS and Operation Periods by adopting fuzzy logic analysis. The same could be applied to the investment revenue V. The proposed model that incorporates subjective judgments and statistical uncertainties may give investors a better understanding of the problem when making investment decisions. Among all the different types of Fuzzy numbers, the choice of using triangular numbers is made for the sake of simplicity, since assuming more complicated shapes may increase the computational complexity without substantially affecting the significance of the results. Triangular possibility distribution can be constructed easily on the basis of little information and its graphical representation can be very simple [8]. Usually, the present value of expected cash flows as well as one-time investment cost (option exercise cost) and customers demand cannot be characterized by fixed numbers. In this paper we consider that the expected values for the investment infrastructure (one-time) costs are in triangular ranges. We fix the peak value of the fuzzy numbers equal to the crisp value of the most expected value and we allow the nearby prices to have some degree of possibility. Particularly, we consider that the one-time costs for broadband business are in the triangular rage (X_L, X_M, X_H), where (X_L X_H) is the range of values (interval of smallest and largest possible value) and the X_M is the most possible value. Fuzzy logic integration with ROs was applied by Angelou and Economides [2]. Fuzzy logic and probability theory are the most powerful tools to overcome the imperfection. Fuzzy logic is mainly responsible for representation and processing of vague data (ill-defined, fuzzy). Probability theory is mainly responsible for representation and processing of uncertainty (randomness). The difference between probability and fuzzy logic is clear when we consider the underlying concept that each attempts to model. Probability is related to the outcome of clearly defined and randomly occurring events, while fuzzy logic is related to the ambiguity inherent in the description of the event itself. Fuzziness is often expressed as ambiguity rather than imprecision or uncertainty and remains a characteristic of perception as well as concept.

The proposed methodology integrates a number of analysis techniques in one decision analysis framework. The target is to recognize business opportunity, to recognize, analyze, identify and plan business evolution options for risk control and estimate the chosen business activity. The steps of the proposed analysis are the following:

The business – opportunity

- Recognize the content of business opportunity for utility companies.

The market analysis

- Specify the local area broadband Services market size and consumers' types and characteristics.
- Specify emerging opportunities for telecommunication services.

Strategy Planning

- Perform SWOT analysis for the specific firm and business.
- Define the risks and the options to mitigate them.
- Define deployment options to control risks and utilize efficiently business strengths and opportunities.

Strategy Evaluation

- Evaluate the deployment options adopting fuzzy logic ROs models.

Strategy implementation, monitoring and fine tuning

- Run the process again as more business related information is collected.

III. A REAL CASE STUDY ANALYSIS

A. Business case description

To illustrate the proposed analysis we apply it to an ICT investment decision for a growing Water Supply & Sewerage Company, which we refer to as WSSC to protect its identity and its projects. WSSC is interested in entering into the broadband business field and exploiting its physical infrastructure (water and sewerage pipes). The specific case study was intuitively discussed in [2]. It is based on extensive discussions between the authors and WSSC ICT management. However, the numbers have been changed by a constant factor to protect firm's business evaluation. In figure 4 we present the SWOT analysis for WSSC and the options involved with these aspects, considering OpCo/NetCo activity. We adopt the pilot and expansion options for the specific cases study. We adopt staged deployment strategy for the network over a 3 year period, where up to 40km of duct/conduits are deployed. Also, a 10 year time-frame is considered in the financial evaluation. Analytically, the deployment stages are the following

- Stage 0 (year 0) **Pilot Option**
  - Pilot network implementing interconnections of selected service provider points of presence within central business district of area
  - Opportunity to connect up to 50 homes/business premises
  - Deployment of backbone and connection of incumbent operator exchanges

  - 8,000+ homes/premises where the duct (conduits) are passed
  - Trial of FTTH/FTTB services with selected Service Providers
- Stage 1 (year 1) **Expansion Option 1**
  - Extension of backbone to other incumbent operators local exchanges
  - 18,000+ homes/premises passed
  - Large scale deployment of FTTH/FTTB services
- Stage 2 (year 2) **Expansion Option 2**
  - Extension of the network to central and eastern suburbs of the area
  - 27,000+ homes/premises passed
  - Growth in FTTH/FTTB
- Stage 3 (year 3) **Expansion Option 3**
  - Extension of the network to western suburbs of the area
  - 36,000 homes passed
  - Growth in FTTH/FTTB

Table 1 in appendix presents the modeling of the cash flows as well as the assumption taken into account. Particularly, second column provides explanations for the various values concerning cost and revenues factors. For the ROs estimation we use a compound Log Transformed Binomial Model (LTBM) [4],[17]. As seen ROs analysis provides higher business values for the overall business deployment strategy comparing to NPV analysis or revenues volatility σ_v=40% and 60%. However, as seen in Table 2 under fuzzy logic ROs and fuzzy logic NPV analysis, even for the ROs result the negative overall profitability is a possibility for the business.

TABLE 2. NPV AND ENPVS UNDER FUZZY LOGIC FOR THE EXAMINED DEPLOYMENT STRATEGY.

Infrastructure one time cost triangular distribution	**X_L**	**X_M**	**X_H**
NPV for the overall business	3.367 €	1.441 €	-485 €
Overall ENPV (ROs) analysis (σv=40%)	3.664 €	1.738 €	-89 €

IV. CONCLUSION AND FUTURE RESEARCH

In this work we provide a decision analysis framework for analyzing business activities for utility companies in the broadband business field. The proposed framework comprises the integration, for the first time in the literature, of a number of well known techniques. Particularly, we identify strengths, weaknesses, opportunities and threats for the business under investigation and adopt ROs that can control weaknesses and threats and exploit strengths and opportunities. In addition, we adopt fuzzy logic to model ROs parameters in a range of possible values as more realistic perspective in real world business. We finally, apply the proposed analysis to a specific case study. As seen in the analysis, typical NPV is not able to value the flexibility offered by the ROs concerning a staged deployment strategy. On the other hand, ROs, extracted by the SWOT analysis, provide higher business value for the adopted deployment mode of the examined case study. In conclusion, the proposed analysis supports decision makers for analysing, designing and implementing broadband business in way that negative investments aspects are controlled and positive ones are exploited for increasing so the business value. We adopt a limited number of ROs types. The analysis should be more complete if more types are included. We may also include a game theory analysis into the proposed decision framework, as this may allow competitors to further develop the SWOT-analysis and would enable a more accurate estimation of the relevant real option values. An extension of our work could also include a multi-criteria analysis taking into account both quantitative and qualitative factors. Finally, the proposed model should be further tested in real cases for recognizing its suitability in the ICT business field.

APPENDIX A

Strengths	**Weaknesses**
• Large scale sewer network in the area with more than 200 facilities with space for installing network equipment • Good quality of man-accessible sewer network - suitable for installation of high capacity ducts/conduits • Large customer base and service points • First to be informed of new building developments – even before incumbent operator • Strong Trusted brand **ROs embedded** • Pilot/Explore, Lease, Growth	• Company structure not yet defined (roles, responsibilities and processes & departments) • Lack of broadband telecommunications business experience • Unknown quality of non-accessible sewers • Organization not yet ready for new business • Lack of sewer/water Network Security **ROs embedded** • Defer, Pilot/Explore, Stage/Expand, Lease, Outsource development and operation, Abandon
Opportunities	**Threats**
• Access European Union Program 2007-2013 • International Strategic Partnerships • First to the market with FTTH • Establish position as first open access network operator • Deploy large capacity networks in shortest time frame with lower cost • Exploit high broadband business growth **ROs embedded** • Pilot. Defer. Growth. Lease	• ISPs, Incumbent or competitors plan to deploy their own fibre networks • Power of the national incumbent in the market • Delay in implementation investment program (allowing other Service Providers of building fibre networks) • Legal/regulatory issues **ROs embedded** • Defer, Contract, Abandon, Expand, Switch

Fig. 4. SWOT-RO matrix for WSSC real case
ROs adopted in the analysis: Defer, Pilot/Explore and Expand

TABLE 1. CASH FLOW ANALYSIS FOR THE WSSC CASE STUDY

Item	Comment		Pilot Year 0	Exp. 1 Year 1	Exp. 2 Year 2	Exp. 3 Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Duct Length Km	First year length of fiber optic network deployment		10	20	30	40	40	40	40	40	40	40
Fibres for dark fibre leasing	Number of fibres available for leasing		12	12	12	12	12	12	12	12	12	12
Fibres for FTTH/FTTB	Number of fibres available for FTTH/FTTB. This is based on the assumed forecast usage of fibre for leasing and FTTH. Based on the forecasts the fibre needs to be provisioned for this case.		12	12	12	12	12	12	12	12	12	12
Increase in Duct Length	It is the yearly increase of Duct length		10	10	10	10	0	0	0	0	0	0
Increase in Fibre kms (dark fibre)	It is the yearly increase of available fiber as dark fiber		120	120	120	120	0	0	0	0	0	0
Increase in Fibre kms (FTTH/FTTB)	It is the yearly increase of available fiber for FTTH/FTTB connections		120	120	120	120	0	0	0	0	0	0
Total Fibre kms for dark fibre leasing	Number of Kms for dark fiber available for leasing to other operators.This is based on the assumed forecast usage of fibre for leasing and FTTH. Based on the forecasts the fibre needs to be provisioned for this case.		**120**	**240**	**360**	**480**	**480**	**480**	**480**	**480**	**480**	**480**
Total Fibre kms for FTTH/FTTB	Number of Kms for fiber available for leasing FTTH/FFTB connections		**120**	**240**	**360**	**480**	**480**	**480**	**480**	**480**	**480**	**480**
Total Fibre Installed kms			**240**	**480**	**720**	**960**	**960**	**960**	**960**	**960**	**960**	**960**
Homes Passed - Potential Customers	Number of hommes the fibers passed along the street		8.570	17.140	25.710	34.280	34.280	34.280	34.280	34.280	34.280	34.280
Increase in Homes Passed - Potential Customers			8.570	8.570	8.570	8.570	0	0	0	0	0	0
Homes/Premises Connected - Customers	A selected number of homes are connected. We assumes for the pilot and each stagle only a selected number of homes are connected		50	300	750	2000	4000	6000	8000	10000	12000	14000
Increase in Homes Connected - Customers			50	250	450	1.250	2.000	2.000	2.000	2.000	2.000	2.000
FTTH - Subscriber Take-Up			0,58%	1,75%	2,92%	5,83%	11,67%	17,50%	23,34%	29,17%	35,01%	40,84%
Customers	Number of FFTH/FTTB customers		50	300	750	2.000	4.000	6.000	8.000	10.000	12.000	14.000
Dark Fibre Revenue												
Dark Fibre Demand km			40	120	300	480	480	480	480	480	480	480
Dark Fibre Lease Available Km			120	240	360	480	480	480	480	480	480	480
Dark Fibre take up			33%	50%	83%	100%	100%	100%	100%	100%	100%	100%
Dark Fibre Revenue/km pa (Euro)	This has been based on prices being charged in other European countries for dark fibre. We have assumed that WSSC is first to build a fibre network across the metro area of the area of interest and effectively sets the price for dark fibre taking also into account the incumbent operator current service.		2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Dark Fibre Revenue (€000)			80	240	600	960	960	960	960	960	960	960
FTTH Revenue												
Revenue per Customer (€/sub/month)	montly cost		25	25	25	25	25	25	25	25	25	25
Revenue per Customer Connection	Fixed one-time cost		160	160	160	160	160	160	160	160	160	160
FTTH Revenue (1000)			23	130	297	800	1520	2120	2720	3320	3920	4520
Profitability												
Total Revenue (DF+FTTH) (€000)			103	370	897	1760	2480	3080	3680	4280	4880	5480
Cash operating expenses (€000)			-306	-435	-538	-614	-633	-652	-671	-691	-712	-734
Maintenance Expense (7% of CAPEX)			-126	-252	-378	-504	-504	-504	-504	-504	-504	-504
Operating Profit			-329	-317	-19	642	1343	1924	2505	3085	3664	4242
Capex												
Duct/m (€)	Estimation price by the market containing some reasonable level of discount. It is an estimation and it includes installation in accessible and non-accessible sewers (ie it is an average cost of different deployment methods). If only accessible sewers are considered then the costs will be lower.		60	60	60	60	60	60	60	60	60	60
Blown Fibre/m (€)	Analysis by the market		0,29	0,29	0,29	0,29	0,29	0,29	0,29	0,29	0,29	0,29
Cost per Home Connection (€)	Analysis by the market and averabe area conditions		200	200	200	200	200	200	200	200	200	200
Optical Equipment (€000)			1000	1000	1000	1000	0	0	0	0	0	0
Duct & Fibre Rollout (€000)			800	800	800	800	0	0	0	0	0	0
Homes Connections (€000)			10	50	90	250	400	400	400	400	400	400
Total Capex (€000)			1810	1850	1890	2050	400	400	400	400	400	400
Capex (one time cost) **X**			**1800**	**1800**	**1800**	**1800**						
Cash Flow Analysis												
Operating cash flow (€000)			**-339**	**-367**	**-109**	**392**	**943**	**1524**	**2105**	**2685**	**3264**	**3842**
Cost of capital (%) for WSSC after taxes	Discount factor r=7%		7,00%	7,00%	7,00%	7,00%	7,00%	7,00%	7,00%	7,00%	7,00%	7,00%
PV of the revenues-operating costs (V)		€ 7.862							Isolated options analysis			Compound ROs
PV of the infrastructure costs		€ 6.421	NPV stage 0	NPV exp. 1	NPV exp. 2	NPV exp. 3	σv	RO exp. 1	RO exp. 2	RO exp. 3		Overall ENPV (ROs) analysis
NPV for the overall business		**€ 1.441**	**-€ 1.225**	**€ 534**	**€ 1.011**	**€ 1.119**	40%	647	1.039	1.277		**€ 1.738**
							60%	775	1211	1474		**€ 1.964**

The NPV at central point for the overall business is 1.441 € while for stage 0 is -1.225 €, stage 1: 534 €, stage 2: 1.011 € and stage 3: 1.119 €.
The ENPV at central point (for 40% uncertainty) for the overall business is 1.738 € while the isolated ROs values for stage 1,2,3 are 647 €, 1.039 € and 1.277 € respectively. As seen for higher uncertainty (60% of revenues) the ROs values are also higher comparing to 40% case.

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