Decision Support System Applied to Mobile Telephony Business

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Abstract — **This work aims to present a decision support system focused on a technical feasibility study through site survey procedure, making it possible to develop better cellular telecommunication business. The proposed architecture is based on the business model known as Mobile Virtual Network Operator (MVNO). The Full MVNO operational model is adopted in order to meet the requirements of the Brazilian National Telecommunication Agency (ANATEL). The developed methodology uses smartphones acting as probes for measuring mobile telephone systems. MVNO subscribers with specific profile may perform active or passive field measurements in real time, thus generating a consistent database which holds the mobile network behavior. The proposed decision support system solution can be used by telecommunication service operators, last mile service installation, system integrators, technological solutions consultants, and sales force team for telecommunication services.**

***Index Terms*— Decision Support System, Site Survey, Mobile Virtual Network Operator, Location Based Services, Universal Mobile Telecommunication System, Mobile Service.**

I. Introduction

SINCE service provisioning is the process which involves new client activation in a network, automatic procedures are desirable in order to establish easy connectivity and rapid user activation.. However, this is not a simple task, since service provisioning is a complex mission for Operation Support Systems. The provisioning survey must consider technical and economical analysis. The former is limited by the existing technologies and the latter by the increase of productivity and cost reduction (peopleware and hardware).

When implementing a data communication service, it is important to analyze all technical features concerning the physical installation, which are provided by the site survey procedure. The aim of site survey is to ensure that the network nodes quantity, location and configuration do supply the required functionalities and afford a performance compatible with the proposed project investment. The procedures described in this methodology allow to decide which site will be suitable to receive equipments and cables (structured networks) or access points (wireless networks), providing all stations with quality connections and full access to available network applications.

Mobile cellular network coverage depends not only on natural factors, such as geographical aspects and propagation conditions, but also on landscape (urban and rural), human behavior, user experience with the operators services, etc. Since the mobile cellular network coverage quality is measured by means of location probability, a precise and reliable forecast of the location by means of radio signal propagation condition is necessary. The collected data result on decisional elements and performance indicators for new business in the mobile telephony area, and might also turn into a strategic advance to evaluate the mobile network behavior. Moreover, post-processing tools supply several data exportation types and personalized reports.

Therefore, this work aims to offer a DSS (Decision Support System) associated with a technical feasibility study through the site survey procedure in order to enhance VAS (Value Added Services) business. The explored feature is the usage of MVNO (Mobile Virtual Network Operator) subscribers as data collection probes for performing an evaluation of the offered services. This self-evaluation provides network monitoring and optimization, allowing real time constant maintenance and benefits to operator clients. This DSS proposal can be used by telecommunication service operators, last mile service installation providers, system integrators, technological solutions consultants and the sales force team for telecommunication services.

II. Related Works

THE MVNO is a mobile operator which does not have its own license for frequency usage and does not necessarily have network infrastructure. MVNOs usually have commercial agreements with traditional mobile operators (MNOs – Mobile Network Operator), which have a radiofrequency usage license. These agreements provide minutes of usage (MOU) to be resale to the MVNO's own final users. To this end, Dewenter and Haucap [1] study the relationship between MVNOs and MNOs. Cricelli *et al*. [2] present a model to analyze the consequences of the diversity in the competition among MNOs and MVNOs. Pattanavichai and Premchaiswadi [3] propose a pricing model for MNO and MVNO's investment in 3G UMTS networks, while Shin [4]

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validate a comprehensive model of consumer acceptance in the context of MVNOs.

The site survey, applications and quality of service are widely studied in literature. Yick *et al*. [5] provide an overview of several new applications and then review the literature on various aspects of wireless sensor networks. Camp *et al*. [6] present a number of mobility models in order to offer researchers more informed choices when they are deciding on a mobility model to use in their performance evaluations. Bedhiaf *et al*. [7] present a downstream application allowing the MVNO to deploy their components more rapidly and at a lower cost. Varoutas *et al*. [8] describe market conditions and dynamics, architectures and the different approaches for deployment of 3G MVNOs as an attempt to address specific advantages and pitfalls.

The present research is deeply influenced by the exponential increase demand for mobile cellular communication observed in Brazil since it owned the right for hosting large scale events such as the soccer FIFA World Cup in 2014 and the Olympic Games in 2016. The Brazilian National Telecommunication Agency (ANATEL) defines two permissible models for exploring MVNOs [9] and also regulates the conditions for exploring the frequencies of 800 MHz, 900 MHz, 1.800 MHz, 1.900 MHz and 2.100 MHz [10].

Large-volume literature is available on decision support systems for mobile commerce, but little concerns mobile network operation. In fact, it was hard to find surveys on this theme since most studies seem to focus on very specific features of mobile telephony business. Hafez and ElDahshan [11] approach the decision support system in telecommunication companies and the reason why they need advanced data warehouse platforms and new technologies. Hong et al. [12] attempt to empirically assess the factors that drive consumers' acceptance of mobile data services. Qi *et al*. [13] propose that each subsystem of the Operations Support Systems is to be equipped with knowledge management capacity, and the knowledge management of the Operations Support Systems is to be realized through its subsystems. On their turn, Qi *et al*. [14] analyze the mobile carriers' competition strategies by using balanced scorecard and system dynamics modeling. Finally, Peppard and Rylander [15] introduce the value network concept applied to the provision of mobile services which is explored to identify potential strategic implications for mobile operators.

III. The Proposal

THIS work is based on the usage of client cellular phones with 3G mobile technology as instruments for data input in a DSS to enhance the Value Added Services of a MVNO. The field data acquisition is obtained by using a software developed for Symbian operating system and installed on a 3G smartphone. This software makes several measures on voice and 3G data service coverage area of network nodes, whatever is the user movement. By monitoring the service coverage signal levels, the geodetic coordinates, and the correct functioning of 3G mobile communication, it is possible to establish both user profile and a methodology for network diagnosis and optimization. The obtained data provide the support for modeling a MVNO scenario for business development. The usage of embedded software in a smartphone is due to the low cost of this hardware and its high portability and usability when employed as a field data acquisition device. These features are desirable since regular site surveys usually use uneasily transported equipments, which are generally expensive, and operated by a highly trained individual.

This work analyses four Brazilian 3G mobile service operators, namely EnterpriseT, EnterpriseO, EnterpriseC, and EnterpriseV, in order to validate the methodology. The data are obtained simultaneously, by using four distinct smartphones, each one subscribed to one of these operators for pinpointing the most adequate 3G mobile service operator. It is essential for the MVNO business strategy to evaluate the mobile operator since this assess provides indicators on the most appropriate partner. Although this research had been developed within the Brazilian context, the same technique and methodology can be used wherever a 3G mobile communication service is available.

Moreover, a Decision Support System architecture is proposed based on the user experience of the telecommunication services to supply voice and data services as well as quality measures. This architecture allows the raw data to be transformed into applied strategic knowledge, creating an information value chain not only for the Chief Information Officers and Chief Executive Officers, but also for every segment of enterprise decision makers.

A. *Data Acquisition and Evaluation*

The data acquisition uses one notebook, one wide band router, and four 3G smartphones with Symbian platform to probe four mobile service operators. The data concerning the area of interest are obtained by using the embedded software running on the four smartphones (Nokia N8, N97, N82, C6) simultaneously, each of which is subscribed exclusively to a different operator. The region where the site survey was performed is composed by different neighboring cities which provide several geographical accidents such as a huge bay, hills, mountains, dense urban sprawl, forests, etc. The mobile network operators' market share for that region at the first trimester of 2012 was [16]: EnterpriseV 24.3%, EnterpriseC 37.0%, EnterpriseT 20.7% and EnterpriseO 18.0%. There were almost 144.03 cell phones per 100 habitants.

The cellular signal observed variables are: date, time, cell identification (CELL ID), location area code (LAC), country, mobile country code (MMC), mobile network code (MNC), latitude, longitude, received signal strength in percentage and dBm, cell name, and cell information. This prototype uses CellTrack [17] to acquire the mobile telephony network information. The smartphone location can either be obtained by using GPS and A-GPS, or by using the CELL ID information, granting georeferentiation of the measured samples.

Several evaluations might be performed using this information: direct comparison between operators, best service identification according to previously defined conditions, 3G and 2G data service stability verification, detection of variables with maximum and minimum peaks. This information on peaks detection is particularly relevant since the maximum and minimum limits of those peaks are associated to service quality.

B. Coverage Field Test

This methodology stage analyses the telecommunication services quality, over a GSM/UMTS mobile network, according to the user perspective, and by using automatic peer to peer measures. These measures are obtained through drive-tests, which mean that areas with deficient or even no coverage at all are considered during the analysis. Moreover, the usage of a unique simultaneous test system to evaluate services allows high result comparability, for both space and time dimensions. Therefore, the proposed methodology provides three fundamental features: (1) peer to peer measures, reflecting technical aspects which influence the service quality; (2) impartiality, since measures are taken on equal conditions for all MNOs; (3) objectivity, since human intervention and decision are eliminated by the automatic sampling.

The networks coverage measurement uses the downlink signal level, that is, the RxLev (Received Signal Level) for GSM and the CPICH RSCP (Common Pilot Channel Received Signal Code Power) for WCDMA along the observed tracks. The 3G/GSM cellular terminals are exclusively dedicated to the task of measuring the effective signal levels, and those terminals are fully capable to take signal samples of all GSM and WCDMA channel from all MVO. The present prototype measurement profile is based on ETSI technical specifications [18, 19, 20].

The prototype evaluation was performed at two scenarios: urban and rural. The former, the urban scenario, begins in *Niterói* City, crosses *Rio de Janeiro*, and ends in *Petrópolis*. This track took 2.1 hours of continuous and automatic measures, covered 110 Km, and visited each city downtown. The latter, the rural scenario, begins in *Petrópolis* City, goes across *Araras*, *Paty do Alferes*, *Miguel Pereira*, *Japeri*, *Seropédica*, *Queimados*, *Nova Iguaçu*, *São João de Meriti*, *Rio de Janeiro*, and ends in *Niterói*. This track took 4.5 hours of continuous and automatic measures, and traveled all over 196 Km. Figure 1 illustrates the GSM/WCDMA network signal level of one operator at urban scenario, obtained by the described methodology. The four peaks reaching 100dBm indicate four signal losses during the tracking.

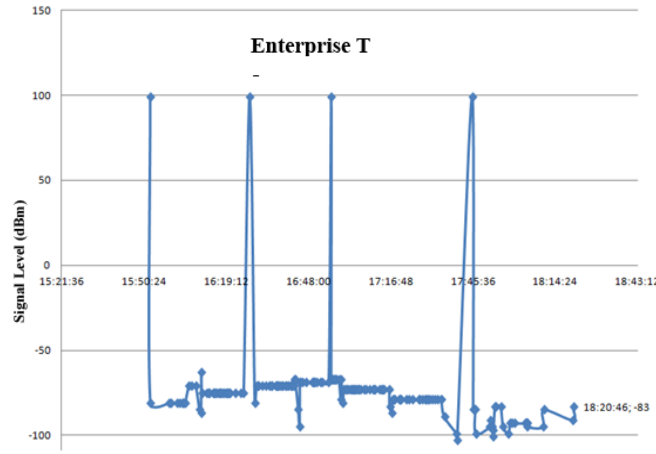

Fig. 1. Signal measures of an operator at urban scenario.

Figure 2 presents the probability distribution of the signal level, also obtained through the proposed methodology. The distribution edge values are within the interval [-75dBm,-85dBM], for urban scenario, as defined by ETSI. However, in rural scenario, this operator seems to be out of this interval, delivering a better signal.

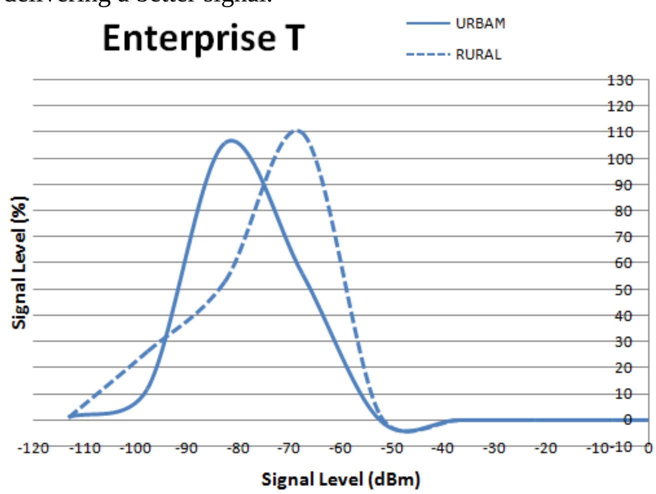

Fig. 2. Signal measures of an operator at urban and rural scenario.

A hypothetical MVNO may use this methodology to produce information about the best partnership, according to its predefined constraints, and its expected user experience. Notice that this driver-test provide information about the MNO service availability on certain locations, as well its quality of service relative to the user point of view. It must be observed that the described procedure yields a kind of snapshot of an operator cellular service provision on a certain location and moment. It is possible that, on a specific place and period of time, and due to some kind of atypical MNO system malfunction, the drive-test could provide unfair measures about that operator signal quality. The authors sustain, though, that this is not relevant, since this situation would have a low occurrence probability, and could be corrected with repeated drive-tests. Besides, system malfunction also affects the user experience of the telecommunication services.

C. *Integrated Cellular Communication Business Architecture*

Information systems need to create an enterprise environment with reliable information flow within the organizational structure. The following architecture, presented in figure 3, describes a full MVNO based decision support system which integrates the benefits of an information system with an assistance tool for decision makers, as it will be explained.

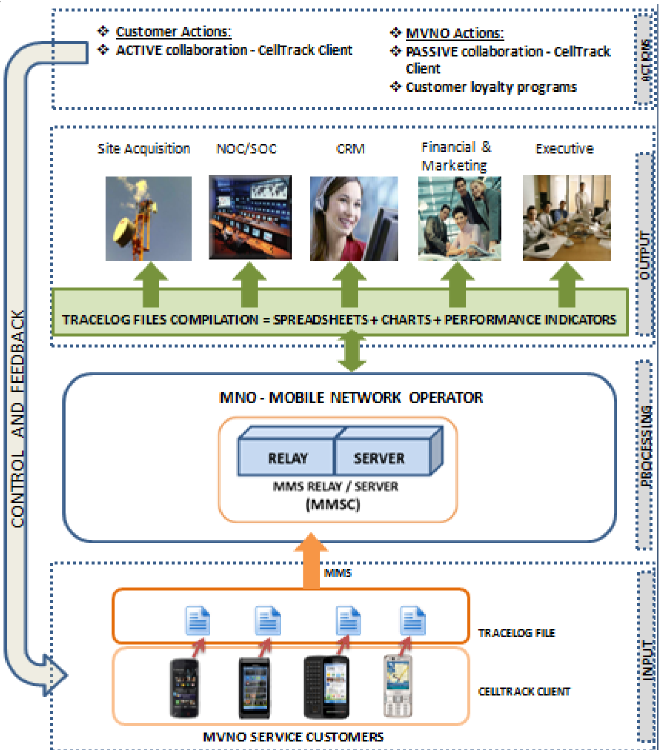

Fig. 3. Decision support system proposed architecture.

The proposed architecture employs smartphones as probes for measuring the mobile cellular telephony system. These smartphones are equipped as described at this paper previous subsection on data acquisition. The mobile network functioning data are stored in a tracelog file, located in the smartphone. Then, the tracelog file is sent to the MVNO through the Multimedia Messaging Service (MMS) using MM1 interface. The file is then received inside the operators' internal structure by the MMS Relay/Server in the Multimedia Messaging Service Center (MMSC), where it is stored and structured on a message database. After that, it is forwarded to the Value Added Services area through MM7 interface, in order to be processed and used by several MNO departments, formatted as datasheets, plots, georeferencing tools, reports and performance indicators.

Concerning the full MVNO clients, they are granted two customer collaboration and loyalty options: (1) an active collaboration, triggered by the client; (2) a passive collaboration, activated by the MVNO.

The active collaboration involves conscious user cooperation. An active field test is performed by the MVNO subscriber by simply running the pre-installed application on his/her smartphone. This application provides real time positioning and signal measures of the voice and data service from the mobile cellular phone system to which the user is connected. That information is logged in the tracelog file and sent by using the smartphone native MMS Client and by addressing the multimedia message to a destination number reserved exclusively to collect such data. For instance, the operator can provide the following instruction: attach the tracelog and send it to the number 48500 with the word TRACELOG in the message text field. In this case, the operator may offer promotional conditions for each client who uploads of the tracelog file. Those promotions may comprehend credits on voice and data usage, points for customer loyalty programs, special discounts on social events and activities, miles at miles programs, etc.

The passive collaboration, on its turn, employs the same smartphone pre-installed application and the MMS Client to perform a passive field test, but with a slight difference. Note that when a subsidized smartphone is offered to the user along with an operating system customized for operator services, its operation is optimized and its environment is automation friendly. Therefore, script and integrated tools can trigger automatic data acquisition and send the tracelog file through MMS without user interference. The time elapsed of system usage and the script activation frequency can be favorably customized to meet the operator's measuring needs. In this case, the user bonus must be greater than the active collaboration model since both data consumption and amount of information on the operator network state may be higher.

However, the passive collaboration has a legal aspect concerning user privacy breach that should not be overlooked. The signal data and the smartphone user location exposition provide information on the voice and data service levels, but also supply a survey on user behavior. For instance, if the passive data acquisition software is activated when the user is shopping, it is possible to set up his/her shopping profile and create a model of user store-navigation style. Vendors may use this model to benefit themselves by trying to shape user needs. Therefore, this business model acceptance must be carefully studied and put to the proof using a small group before turning it into a large scale service.

Those two collaborations support the business model and the proposed architecture in order to minimize the operational costs of maintenance windows and the dispatch of technical teams for real time control of the mobile network behavior. The data acquisition, the information processing, the results compilation, and the operator performance indicator make provision for creating new solutions and services, planning strategic actions and making executive decisions. The operator departments which may benefit by this kind of DSS are:

- *Site acquisition*: it can choose better locations for new sites implementation, maintenance, and network optimization;
- *Network/Security Operations Center* (NOC/SOC): it can execute network failure identification and

network data security policy interventions;
- *Customer Service*: it can assists clients on probe system usage, products offering, and technical calls;
- *Marketing*: it can combine the information with a demographic survey to identify new products to be offered by the operator to specific potential new subscribers;
- *Financial*: it can perform a billing system optimization and a tuning of the return of investment;
- *Executive*: it can obtain performance indicator of telecommunication market to produce better aligned MVNO directives.

IV. Proof of Concept

FOR evaluating this proposal, it will be considered an active collaboration model for the full MVNO client. It is described as proof of concept, beginning with the data dispatch from the smartphone to the information process by the MVNO Value Added Services area. As described at previous subsection (III.A), four smartphones send tracelog files containing signal and position measurement data to a remote server, which plays the role of a MVNO MMS Server/Relay. In figure 4 it is presented the graphical visualization of a drive-test survey which can improve the service provisioning analysis. In this sample, Google Earth [21] was used as cartographical platform, the scripts were developed in KML language [22] and a popup balloon message functionality was provided to specify the band access type, such as WCDMA (Wideband Code Division Multiple Access).

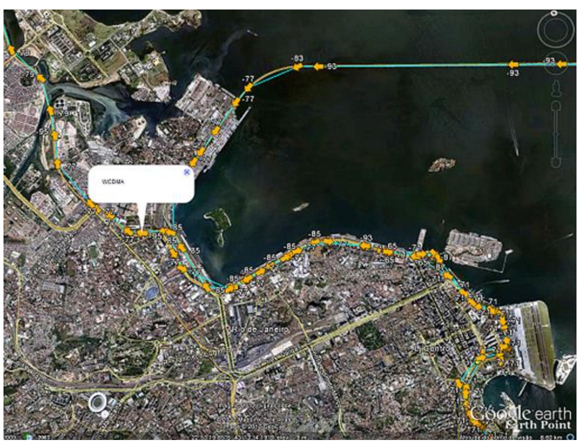

Fig. 4. Coordinates from a KML script plotted with Google Earth.

The user who holds the four mobile phones, known as USER-POC, activates the embedded software on all his/her smartphones starting the measuring process. Some hours later, for instance, the USER-POC terminates that process and activates the MMSLocation software [23] responsible for dispatching the trace log file to the operator. Since we did not have an MVO partner to provide us the Multimedia Messaging Service Center with a MM1 interface, we stored the messages in an ordinary email server. Then, the tracelog file, in plain text format, is received by the subject-matter specialist on value added services (SME-VAS) through the MMS Relay/Server MM7 interface. Once again, since a real MMS Relay/Server was not available, we simply downloaded the messages from the email server. Afterward, the tracelog file is processed in order to produce the worksheet (PLAN-POC).

Figure 5 presents a MVNO client called USER-POC, the specialist responsible for the MVNO data processing for Value Added Service (VAS), the data content (DATA-POC), and the worksheet (PLAN-POC) which will provide input for the georeferencing system, business intelligence system, and mobile network planning and optimizing system. By the time the SME-VAS access the tracelogs contents and compile them into a worksheet, the absence of a MVO partner is overcome. All post-processing is performed exactly as it would be in a MVO/MVNO operator.

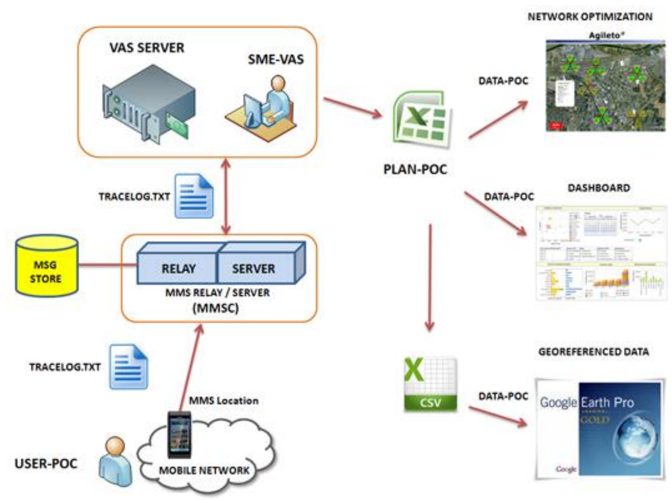

Fig. 5. Proof of concept schematics.

This POC uses online business intelligence software [24] to provide dashboards, whose inputs are the data content (DATA-POC) exported from the PLAN-POC worksheet. Those dashboards provide at a glance views of key performance indicators relevant to a particular objective or business process. Thus, the information can be presented to the stakeholders by using several types of graphical representation.

The mobile network optimization deals with settle down sites with their already functioning antennas, attending mobile client in constant evolution. Therefore, the optimizations tasks become harder to accomplish through time. Once the network is operative, its performance is monitored using key performance indicators. After the data analysis, a fine tuning is carried out producing new parameters which are applied to the network. This fine tuning consists of studying features such as the power control, signal quality, handovers, clients' traffic, resources availability and access availability.

This work uses a desktop real time application [25] specially designed for network optimization, a network device independent 2G and 3G tool. The PLAN-POC is imported to the application and this optimization tool provides functionalities such as network auditing, network visualization, network optimization, georeferenced investigation and georeferenced representation. Once the optimization analysis is finished its results are exported to the cartographical platform [21]. Figure 6, for instance, illustrates the antennas outlines which provide 3G services during a drive-test.

Fig. 6. Snapshot of antennas outline

V. Conclusion

THIS work proposed a decision support system architecture with georeferenced information management and measures of the 3G data services coverage level, which compiles Fazzioni's [26] research.. The acquired data are subjected to quantitative and graphical analysis in order to identify the best 3G data service coverage available and to provide information for a MVNO business implementation. Moreover, the proposed architecture takes into consideration Value Added Services components which extrapolate the usual graphical representation of signal measures used to support site surveys. The real time loading of signal levels measures, by using clients' smartphones along with a computational infrastructure can reduce the workload and the operational cost of operators' maintenance teams.

As observed on the presented proof of concept, this work offers an architecture that provides a single system integration of heterogeneous data sources, information visualization and Value Added Services. Therefore, it is possible to use this architecture to support the MVNO telecommunication service management planning and decision making.

In the future, this work will investigate alternative business models that are likely to emerge from the fourth generation technology (LTE) implementation and the corresponding new technical requirements. Furthermore, it is interesting to exploit large experiments with the proposed platform in order to provide a better understanding about the mobile telephony system evolution, featuring performance, quality, scalability, and return of investments. Besides, new smarphone embedded platform prototypes may be developed for other operating systems such as Android (Google), iOS (Apple) and FirefoxOS (Mozilla).

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