

Elevate the experience

Improve customer experience with next-generation management



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Communications and service providers need new networks and service analytics solutions—based on advanced analytics functions and using Big Data—to simplify network operations and improve the customer experience. Analytic solutions enable operators to automatically perform root-cause analysis when the experience is degraded.

The telecommunications business faces many challenges these days. The exponential growth of mobile traffic has put a lot of pressure on telecommunications networks. The combination of traditional sources of revenue declining, exponential growth in data traffic, increasing network complexity (4G, 3G, 2G, WiFi, and femtocell), and the explosive growth of services and connected devices are becoming too much to handle. They overwhelm a company's ability to provide high-quality service assurance—a situation that can damage customer relationships and increase churn.

In this new scenario, tradition service assurance approach, where the user experience is managed by monitoring the network, is not successful anymore. The equation good network service-level agreement (SLA) = good services is no longer valid. To meet increasing customer expectations in today's hypercompetitive telecommunications world, service providers must shift their focus. They need to move from monitoring and managing network SLAs to monitoring and managing the end-to-end service quality as it is perceived by the final measure—the customer quality of experience (QoE). Provider service assurance organizations must face the well-known litany of challenges to go from the SLA to the QoE.

In this transition, Big Data plays a double role:

- From one side, the explosion of the data to manage is a big threat.
- From the other side, Big Data and the statistical techniques need to manage and analyze it all.

This dilemma presents service provider organizations not only the great opportunity for growth but also the biggest challenge to better optimize and automate their business processes.

This paper explores how combinations of Big Data and advanced analytics can dramatically transform network problem identification (root-cause analysis) and solution recommendations from a manual, time-consuming process to an automatic and actionable one.

Traditional approach to user experience management

To better understand how Big Data and analytics can dramatically improve the network problem identification and resolution for service providers, let's show how the customer experience is managed by telco operators.

In the telecommunications industry, the management of the user experience is traditionally a well-established discipline with clear models and processes, such as the enhanced telecom operations map (eTOM) and Information Technology Infrastructure Library (ITIL). It is generally based on three main business processes:

- **Fault management**—It is the group of processes collecting and managing alarms from network and service elements. Generally speaking, fault management is responsible for monitoring services availability. This process is highly automatized.
- **Performance management**—It is the group of processes collecting network and service performance information and aggregating it in high-level indicators: key performance indicators (KPIs) and key quality indicators (KQIs). This management is responsible for monitoring the performance quality of the services. It is highly automatized as well.
- **Incident-and-problem management**—It is the group of processes that identifies the problems (root-cause analysis) and makes the needed changes in the network to fix the problem. It is manual and time-consuming.

The idea behind this model is very simple: All services are mapped into the network and are associated to aggregate performance indicators (KPI/KQI), which measure the quality of the service provided. The combination of these components—network alarms, KPI/KQI, and service-network element mapping—provides the information to manage the service quality.

- KPI status provides clear and integrated view of the network and the service quality delivered.
- Network failure alarms and KPI violations provide immediate messaging on problems.
- Network-service mapping enables root-cause analysis when alarms (network and KPI) are raised.

When a network element fails, alarms are raised. Through the mapping between service and network elements, it is possible to identify impacted services. Similarly, when a service KPI or KQI is degraded—going above or below defined thresholds—the violation alarm is sounded. Through the service-network mapping, it is possible to identify the cause of a problem. The combination of alarm, KPI, and service mapping enables providers to manage network problems and incidents in subscriber services.

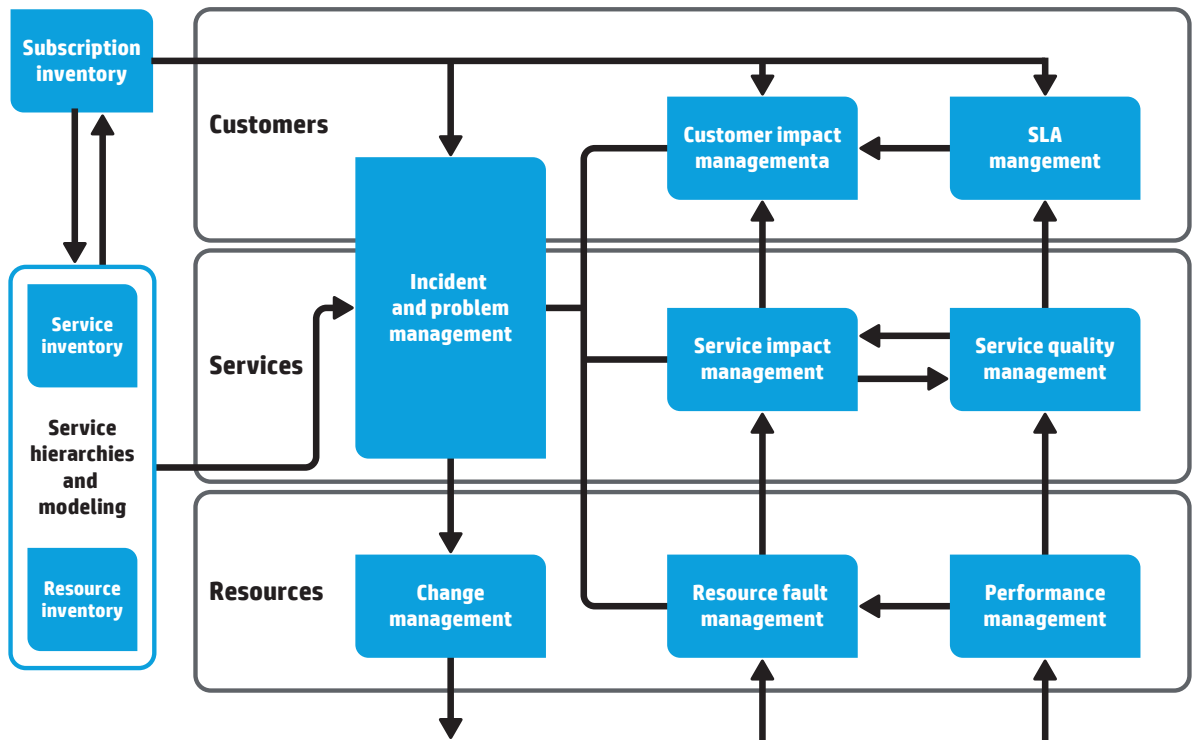
From Network to Service

The diagnostic approach, based on the mapping between services and network elements, is referred to as the “abductive inference” model between alarms (effects) and network elements (cause).¹ In theory, this model is extremely powerful. In reality, however, it has several strong limitations, such as:

- Mapping can be extremely complex in large networks
- Diagnoses only known problems (the ones modeled)
- Fails to provide user impact information
- Cannot identify problems that have no fault associated with them, such as a slow download

The picture below shows an example of telecom operator service assurance reference architecture and the associated business processes.

Figure 1. Example of telecommunications reference model for assurance and fulfillment processes



¹ Abductive Inference is the process of reasoning from effect to a cause. It is a form of logical inference that goes from an observation (an alarm) to a hypothesis that accounts for the observation (the network or service elements that caused the problem).

This model has worked well until the mobile Internet era. In the 2G and 2.5G world, all or most part of services—such as voice or SMS from telecommunications operators—were network services. These services were controlled end to end by the provider, from the switch to the terminal. Moreover, at that time, the mobile network was quite homogeneous and terminals (phone) were quite unsophisticated.

In 2/2.5G scenario, the quality of the services was tightly bound to the network service level: Monitoring the network in particular, the network signaling—was enough to check the quality of the services provided. At the same time, the strong relationships between services and network elements were the key to identify the root cause of the problems. It was the era of service-level contracts and key performance and quality indicators.

With 3G and the beginning of the mobile Internet era, this scenario changes: Non-network services begin to appear. IP services—such as email, web browsing, file download, and more—started to become a commodity also on mobile networks. These new services had the peculiarity to not be network services. Instead, they are application services provided by apps on top of the network.

Quite often, these applications are not owned by operators but are provided by external entities (application providers), using the operator network. The terminal starts to be more intelligent and run part of the applications and services on the terminal itself. The first smartphones appear. Mobile networks increase their complexity: The 3G network is a combination of packed data and voice-circuit networks. Its infrastructure coexists with the current 2G and 2.5G networks.

These changes have a strong impact on the user experience monitoring and assurance:

- The new IP services are just tightly bound to the network layer. Monitoring the control plane is not enough. User plane information is needed, too.
- Moreover, the relationship between services and network elements becomes less clear due the intrinsic packet-switched behavior of IP protocols, making the problem diagnostic processes extremely complex and time-consuming.

The service monitoring and assurance systems evolve to switch their focus from network to user, and two new concepts arise: the quality of experience and customer experience management (CEM).

From Service to Experience

QoE is a measure of a customer's experiences with a service—be it web browsing, phone call, TV broadcast, or other things. QoE is a purely subjective measure from the user's perspective of the overall value of the service provided. That is to mean QoE cannot be taken as simply the effective quality of the service. It also must take into consideration every factor that contributes to overall user value—such as suitability, flexibility, mobility, security, cost, personalization, and choice. Apart from it being user dependent, QoE will invariably be influenced by the user's terminal device (for example, low-definition or high-definition TV), user's environment (in the car or at home), user's expectations (cellular or landline), and the nature of the content and its importance (a simple yes/no message or an orchestral concert) [Wikipedia].

Even if the QoE is a subjective measure, it is possible to identify metrics that are directly related to the quality perceived by the end user. They include time to set up a new call, time to see a new web page or to access Internet content, and jitter or video buffering time when watching a video. These metrics can be combined in score system to be used as global indicator of the quality perceived by the subscriber when using the services—and when interacting with the service provider itself, such as contacting customer care.

The arrival of 4G networks and the “apps era” completely reverses the traditional scenario: Only a few services are still network services. Most of the services are provided by application over the network through over-the-top applications.

- The first and worst consequence of this new paradigm is that telecommunications providers don't control the end-to-end service anymore. In the best case, they just control some components of this services. In the most cases, they just control the flow of application data inside their networks. But at the same time, subscribers still credit service providers for the end-to-end service. If a subscriber has a problem with YouTube, the first thought is that the network's operator is not good, independent of the real reason of the problem.
- In the case where the service provider controls the whole end-to-end service—such as VoLTE—providing a clear view of what is the real service quality perceived by the final user isn't an easy task. The coexistence of different network technology—4G (fully IP), 3G, or 2G (traditional) and also WiFi—has dramatically increased the complexity of measuring service quality. Through a mix of different network technologies, a VoLTE call can provide the so-called 3g/4G roaming—and in this case, understanding the quality of the call is a real guess.

- The user interaction is completely changed, too: Subscribers and their devices are always connected to the network—and always on. As a result, customers are becoming extremely demanding in terms of quality and speed of the connectivity.
- Additional complexity element to this new scenario is related to the so called Internet of Things (IoT). In the near future, the main users of the telecommunications network will be not human anymore, but sensors and devices. This is the era of machine-to-machine (M2M) communications.

Obviously, service monitoring and assurance systems must evolve to keep up with this scenario:

- New data sources have been introduced (usage plane) to produce new KPIs and KQIs, correlating control and usage information.
- Session capture and monitoring have been extended to all subscribers.
- Deep-packet inspection (DPI) probes has been introduced in the network to extract IP protocol's meta data to have a better view of the user traffic at application and protocol level (level 7).
- Some operators have started to use device status information (CiQ) to extend the troubleshooting up to the user's devices.
- Other data sources can include network topologies and logs.

Unfortunately, most of these improvements have been focused on identifying and monitoring the subscriber's quality of experience. Relative few efforts have been directed to solve the fundamental problem of the network and subscriber management: understand the reason why a problem or alarm has happened.

Using statistical terminology, today's service assurance systems are efficient QoE descriptive measurement tools (know the problem). They, however, they don't provide diagnostic analysis support (help solve the problem).

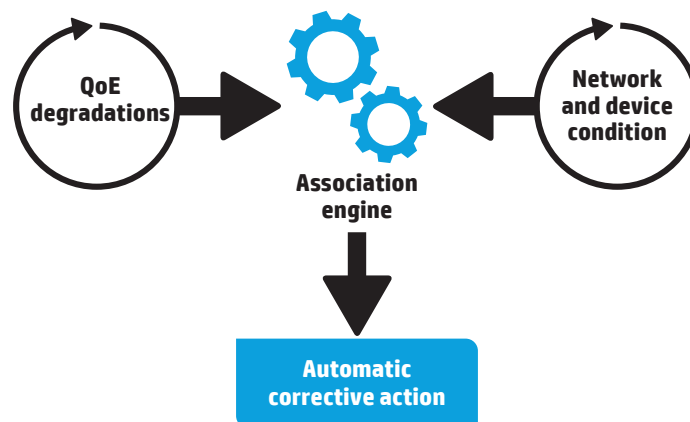
Moving from knowing the problem to solving it

Moving from knowing the problem to solving it, implies that customer experience management tools must evolve from deterministic performance measurement tools to statistical-based ones.

To bridge the gap between QoE and network status conditions, customer management systems are required to provide:

- Automatic diagnostic analytics methods to identify the root cause of the issues or accidents
- Descriptive analytics methods improvement to support diagnostic analysis, such as new KPIs and KQIs usable for diagnostic aspects
- Recommendation analytics methods to automatically provide the corrective actions to solve the identified issues
- Predictive analytics methods to anticipate future issues and to support recommendation analysis

Figure 2. Scope of automatic QoE violation diagnostic tools



Solution overview

HP Smart Profile Server (SPS) analytic platform is a new generation of customer experience management system, enabling deterministic and associative/predictive models and techniques to derive insights. These insights then can be used for better customer experience assurance and automatic problem determination and solving. It uses advanced analytics engines and specialized telco models to:

- Build a coherent and complete view of the customer, expanding descriptive analysis at application level
- Dynamically and automatically understand how customer issues are related to service elements to provide real-time recommendations on how fix them

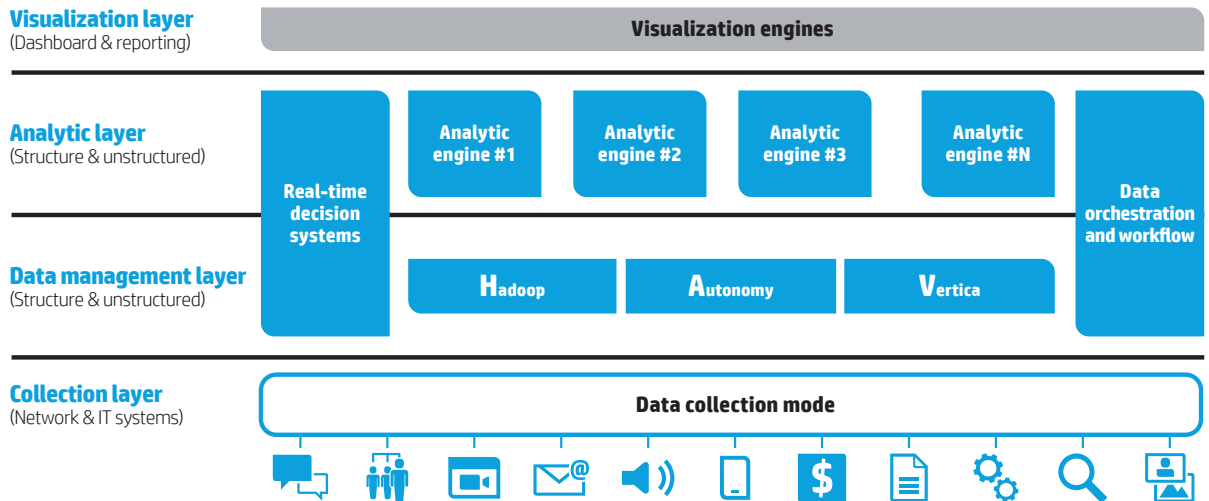
The HP solution goes beyond today's CEM solutions, where analytics components determine that some user experiences are degrading, but the operator has to manually examine the reasons. Rather, the HP solution optimizes and automates the whole business service assurance processes: collect information from across networks, proactively analyze for QoE violations, automatically identify and score the root cause of the problem, and recommend the action to solve the issue.

The HP SPS analytic platform consists of these logical modules.

- **Data management module**—Responsible to collect and prepare user, network, and service activities. It collects data from:
 - Network plane—radio access, user sessions, and PDP context
 - Protocol and application usage—application data used by subscribers
 - Devices—operational data, battery level, radio signal status, and call drops
 - Other network sources—BTS radio signaling strength
 - Reference information—location, subscriber, plans, services, and device information
 - Social media (optional)
- **Analytics module**—Contains the analytics engines and models for deterministic, associative, and predictive analysis.
 - QoE engine—Provides KPIs showing the real view of the quality perceived by the subscriber.
 - Classification-and-clustering engine—Responsible for the alarms collection and classification in groups by similarity.
 - Associative engine—Analyzes data from different sources to find hidden association among QoE violations and networks conditions. It performs a precisely targeted, root-cause analysis when the user experience degrades.
 - Recommendation engine (or feedback module)—Identifies and recommends the best action to execute to solve the issues.
 - Root-cause analysis model—The model used by the solution.
- **Real-time decision engine**—Interacts with telco system to actuate the action suggested by recommendation engine. It is based on CEP component, which correlates the events together. When a significant pattern occurs, it triggers a real-time decision, interacting with business logic module.
 - Business logic module—Additional rules used to select actions from a group of recommendations. For instance, if the recommended action is to offload on WiFi the users who are watching YouTube, the business logic can be used to select the user to move first.
 - Complex event processor—Performs standing queries (online processing) on data streams, correlates multiple event sources, and detects complex patterns across those sources over large volumes of data.
- **Visualization module**—Shows all the data and analysis results in a graphical form. It enables drill-down analysis, data exploration, and subscriber views.

HP SPS runs on HP HAVEn Big Data architecture, which provides the software technology infrastructure for managing in real-time Big Data and fast analytics.

Figure 3. HP SPS logical architecture



HP SPS enables communications service providers to determine what is affecting their customer experiences and resolve them before users call to complain, increasing customer satisfaction and loyalty by:

- Monitoring and measuring the customer experience in real time
- Performing automatically a precise root-cause analysis when the user experience degrades
- Recommending the right action to perform properly in the network

Data management module

This module collects data about customers across different telco infrastructure, including customer’s devices—and eventually, also from social media—and prepares them from statistical engines.

Data preparation for statistical and predictive analysis is a key activity done by the data management module. Through this process, all the various data sources are prepared to be used effectively by the analytic module. Some examples of this activity are:

- **Data cardinality²**—To assess service assurance degradation, many of the collected data sources need to have a reduced cardinality size to achieve precise analytic outputs. For instance, from a time period of network or device errors, the data management module would reduce time of fault from 1:12:33 a.m. to a time bucket of “early morning” or 1 a.m.-3 a.m. window. This step enables the analytic module to be more precise in the classification, clustering and association of root cause between the data.
- **Data hierarchy**—This is the process of establishing a hierarchical model to the various data elements used as reference information for service assurance analytics.
- **Data correlation**—For the reason already presented, it is not possible in the new telecommunications architecture to track customer experience using a single data source. Multiple data sources have to be gathered and correlated to provide a complete vision of the subscriber activity and experience. For simplicity, we will not identify the data source at network elements (such as GGSN, MSC, HLR, and S-CSCF), but we will use the IMS concepts of control plane and user plane. Control plane consists in all network entities involved in controlling establishment, usage, charging, and termination aspects for communication services. The user plane is composed of the network entities that process and transport media.

Three groups of information are particularly important to efficiently manage customer experience management: control plane, user plane, and device status information.

- **Control lane information**—Control plane provides all the call control and authentication functions for call setup, handoffs, and billing recording. This information is fundamental to know how the network and network services are working. From protocol point of view, the control plane is a mixture of pre-IMS signaling protocols, such as SS7, IS-41, and TCP/IP (SIP and Diameter).

² “In mathematics, the cardinality of a set is a measure of the “number of elements of the set”. For example, the set A = {2, 4, 6} contains 3 elements, and therefore A has a cardinality of 3 – from Wikipedia

– Due to the layered design of IMS, control plane entities are not aware of the user plane traffic volumes. User plane entities are not aware of the status of control plane signaling needed to correlate control and user plane information to have a complete view of what happens on the network.

• **User plane**—This plane provides information on mobile data channel, which bears all the IP services and applications used by subscriber, such as Facebook chat, web browsing, or YouTube. Extracting information from this plane enables creation and monitoring of KPIs and KQIs on the Internet and application services from operator networks. The user plane uses only IP protocols.

– This is the only data source to measure the Internet and IP application QoE.

• **Device status information (Carrier iQ)**—Device operational information is measured directly on the mobile devices and provides an important perspective of what is really perceived by users. Correlating this information with the previous two sources enables evaluation of the impact of networking issues on your customers. More important, it enables the discovery of problems that are not related to network issues, such as service degradations and device-specific issues. Correlating device information with network ones creates a complete view of the user experience and the network and service situation.

To increase the efficiency of the model, other data sources can be combined, such as:

- Personal and billing information for subscriber profile for priority selection
- Network elements status to correlate QoE analysis with radio signaling power and alarms
- Social media for brand protection and fast discovery of problems

In the table below, a summary view of the main data sources used by HP solution is provided, along with a breakdown of how this data are used.

Table 1. Data source in use by HP solution and their roles

	Examples of data	Gathering main goal	Data source limits
Control plane info	Network accessibility, RAN access (2G/3G), 2G retransmission, 3G CQI, RF quality, PDP context, uplink/downlink throughput, and handovers (Ho)	This data source provides information to create network KPI/KQI and how the network is working.	This data source presents two main limits for customer QoE: <ul style="list-style-type: none"> • Doesn't provide any information on QoE at application and protocol levels (just at PDP context). • Correlation between network data and subscriber QoE is quite complex and limited.
Usage plane info (user data)	Web browsing, YouTube, Facebook (http), email protocols, and ftp	Through this data it is possible to define the QoE on data channel; analyze the quality of IP applications used by customers	Only information on data-channel performance
Device information	Device operational data, call drop, and CiQ	Collect data on device's status (radio signal strength, battery) and the call status	Concern on privacy aspects limits the information gathered to device status voice call (2G, 3G, and 4G). No information on data and application traffic.
Location-based information	Real-time information of customer, device, position (outdoor and indoor)	This data source provides location information to associate previous groups of information to improve diagnostic capabilities, using location and geospatial data.	Data to augment the information available
Subscriber personal and billing information	Subscriber personal information, billing, and preferences	Identify the subscriber profile from operator point of view, such as high spend or business	Just static information on the subscriber
Network status information	Radio signal by BTS, network elements status and power	Enhance the diagnostic level of the platform, including low-signal or environmental situations	Not applicable
Social media	<ul style="list-style-type: none"> • Customer sentiment analysis for brand analysis and protection • Social media information and related customer problems 	Social media investigation to discover problem not identified with other methods (people who wrote on Twitter about problems they have on the network).	Very complex to correlate at the subscriber level. To associate a post to a subscriber's identity (MSISDN) requires privacy opt-IN authorizations that are difficult to obtain.

To gather these data sources, HP SPS solution uses HP eIUM (real-time mediation and ETL). Information is collected from network elements (traditional and IP ones), DPI probes, IT (DBs and logs), and HP IDOL social media collector to pool information from social media.

Analytic module

At the heart of the HP SPS auto root-cause, diagnostic analytic solution is the analytic module. It uses extremely sophisticated analysis model and engines to manage the best prediction.

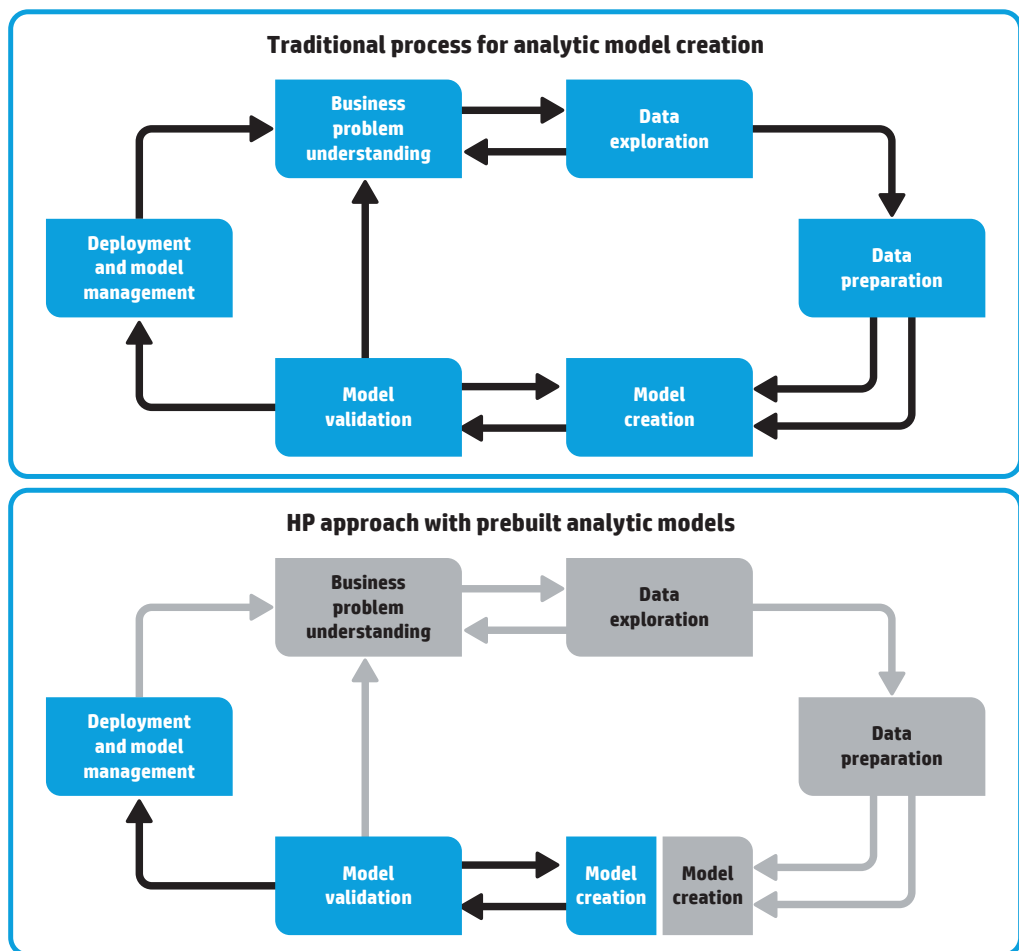
Key components of HP SPS auto root-cause, diagnostic analytic solution are:

- Analytic model
- Analytic engine

Analytic model

Unlike most parts of analytic solution in the market, where the model is built during the preliminary phase of the project, HP SPS comes with its analytic models already built-in, which leverages the experience done in other operators. In this way, the first and more complex phase of any analytic project (data discovery, pattern identification, and analytic model creation and test) is dramatically reduced: existing data are directly inserted in the model and the model is adapted to them.

Figure 4. Traditional analytic approach vs. HP one



As shown in the diagram, the HP approach to use prebuilt analytic model for root-cause analysis for customer experience management reduces the implementation time and focuses the activities on the model deployment and result analysis.

Analytic engine

HP SPS auto root-cause, diagnostic analytic solution uses several engines to analyze the information gathered, identify the problems, finds the root cause of these problems, and proposes the best action to solve them.

The description of this engine and how they work together is provided below.

- QoE engine**—It provides subscriber, service, and network KPIs, showing the real view of the quality perceived by the subscriber. QoE engine has the capability to collect enormous amounts of data from the control and user plane, devices, and other sources. The engine can correlate them and create an insightful aggregation and statistical view of these data, and finally generate results. In HP SPS Analytic module, the QoE engine is implemented as an analytic engine capable of aggregated and transformed statistics collecting and managing data coming from different systems.
- Classification engine**—Classification engine automatically builds highly accurate cluster groups and categorization for KPI/QoE violations, alarms, issues, and eventually network conditions—classifying them in groups by occurrence. The scope of this classification is to automatically identify the failure and condition groups. It is based on clustering techniques, using the already prepared data sets.
- Associative engine**—It performs a precisely targeted root-cause analysis when the user experience degrades. HP Associative engine analyzes data from different sources to find hidden relationships between QoE violations and networks conditions.³ The methods used are similar to market basket analysis, which find rules associated with frequently co-occurring items. In this case, the engine will look at co-occurring network conditions, alarm, and more—with the QoE violation, based on the prepared data sets.
- Recommendation engine (or feedback module)**—Once the various association rules and common occurrence to the root cause is determined, the recommendation engine is responsible for identifying and recommending the best actions to solve the issues. It is based on content-based, filtering-statistic methods.

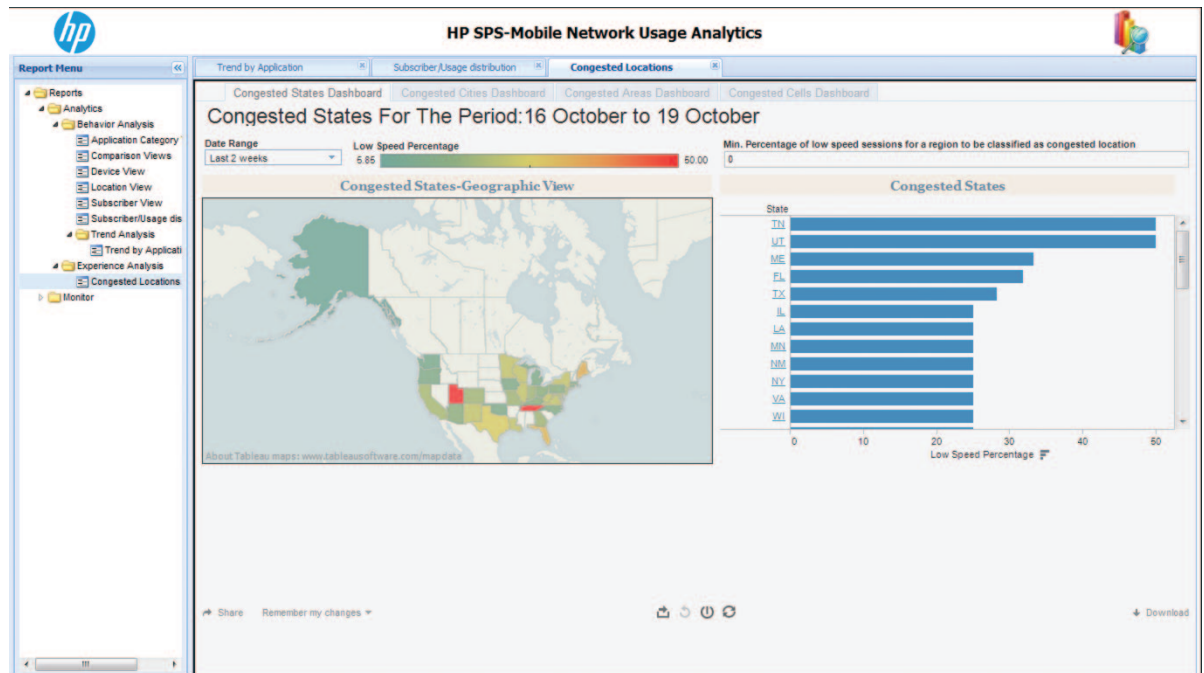
Real-time decision engine

The actions suggested by recommendation engine have to be matched with business rules and other situations happening on the network. The real-time decision system is in charge to select the right action—taking into consideration not only the single problem, but also the rest of the environment.

Visualization

The visualization engine is a dashboard showing all relevant data of the platform.

Figure 5. Example of dashboard



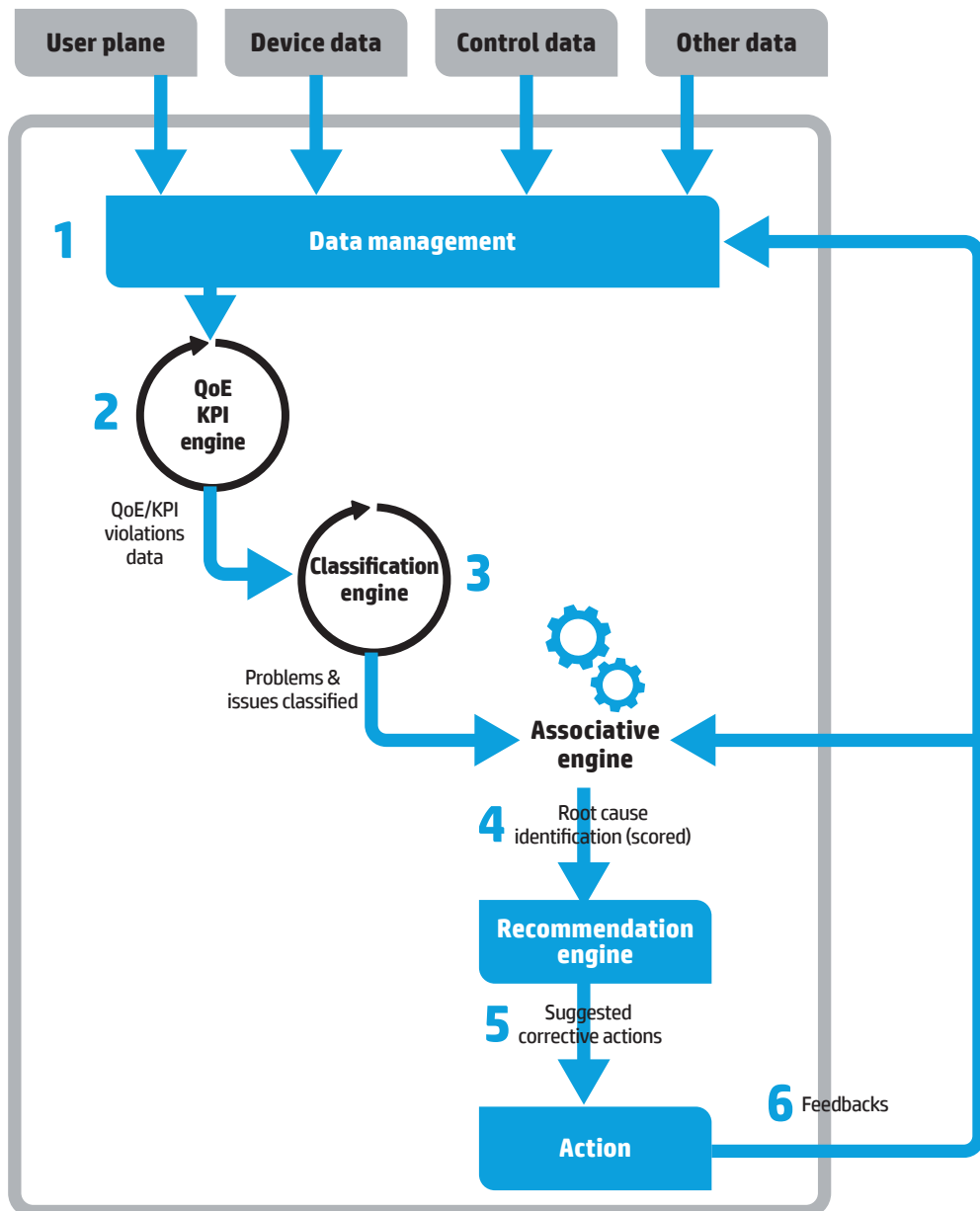
³ In statistics, an association is any relationship between two or more measured quantities (variables) that are statistically depended. The term association is, therefore, closely related to correlation. Both terms indicate or imply that two or more variables differ, according to some patterns. Association refers to a more generalized term while correlation can be considered as a special case of an association, where the relationship between the variables is linear in nature.

How it works

HP SPS auto root-cause, diagnostic analytic solution is a staged machine, performing several steps to produce its result. The picture below shows all six stages:

- **Stage 1**—It is the preparatory phase, where the data collected from the data source are loaded in the management module. Here, the data are filtered, purged, normalized, and correlated. Data are prepared for statistical use in next modules.
- **Stage 2**—Prepared data are loaded in the QoE engine, which will use it to create analysis showing the experience perceived by customers using services.
- **Stage 3**—The classification engine automatically will group data from Stage 1 by failure groups.
- **Stage 4**—It is the core phase, where the groups are analyzed to find the rules that will identify the root cause of the QoE violations.
- **Stage 5**—It is where the system provides recommendation for the action to solve the issue.
- **Stage 6**—It is a feedback loop to control the soundness of the recommendations and to improve the whole process.

Figure 6. SPS auto root-cause analysis solution workflow



Stage 1: Data management

The data management module is a continuous process, receiving data gathered by telco data sources and preparing it for further statistical analysis modules.

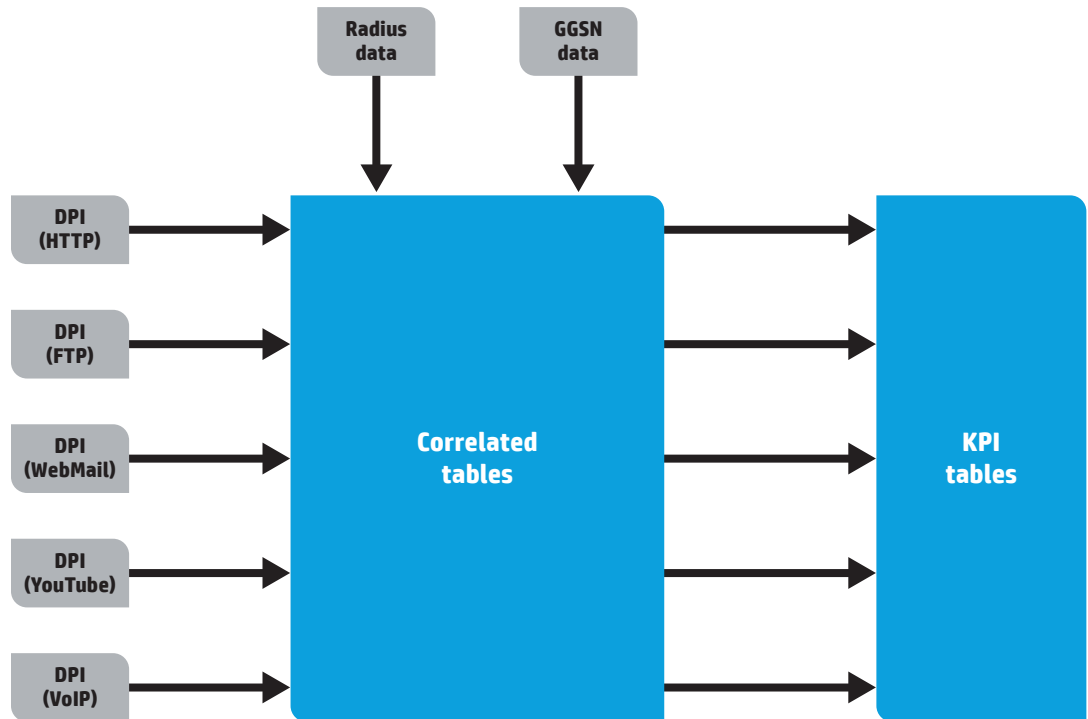
HP data management module has two main scopes:

- Prepare the data for QoE KPI engine
- Correlate data to network and device information to abilitate the automatic diagnostic engines

Prepare data for KPI/QoE engine

Since a single data source cannot provide all the needed information, the data management module is in charge to correlate different data source to fill missing information. Particular care has to be used to produce data to monitor over the top and more general Internet services. To monitor these services, DPI data sources must be used in correlation with control plane information. An example of such correlation is provided in the picture below, where GGSN session and radius information are correlated with DPI-gathered traffic (ftp, http, webmail, YouTube, and VoIP protocols) to create customer experience QoE KPI for Internet and application services.

Figure 7. Example of user plane/DPI correlation and transformation in QoE KPI



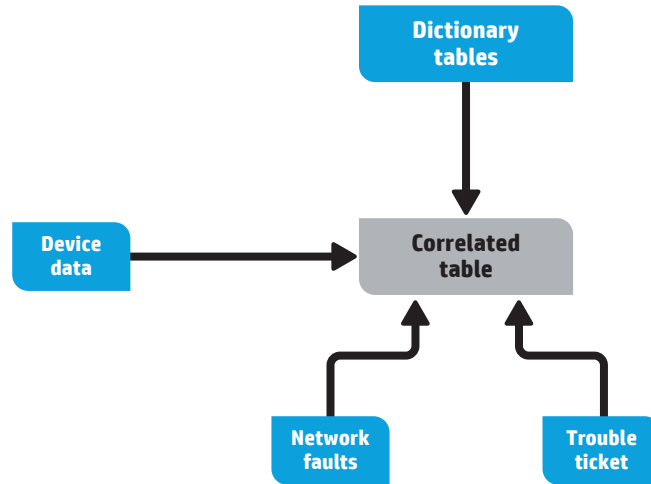
When input data are missing or partially missing (collection phase failed or missing files), supervised learning models (SVM) can be used to analyze data and recognize similar patterns. Using a set of training examples, an SVM training algorithm builds a model that assigns incomplete items into one category or the other.

Correlate data to network and device information

The second goal is extremely important as it associates all information collected to create QoE KPI with the network and device conditions. The data used for the creation of KPI also are enriched with network and/or device information to abilitate the other HP SPS engine to the automatic, diagnostic root-cause analysis.

An example of this second process is shown in the picture below, where device data information—before being aggregated and transformed in QoE KPI—is enriched with network faults and trouble ticket to create a more complete set of information for the diagnostic phase.

Figure 8. Example of device information correlation with network data



The output of this phase is the enriched data, containing QoE data and network and device conditions.

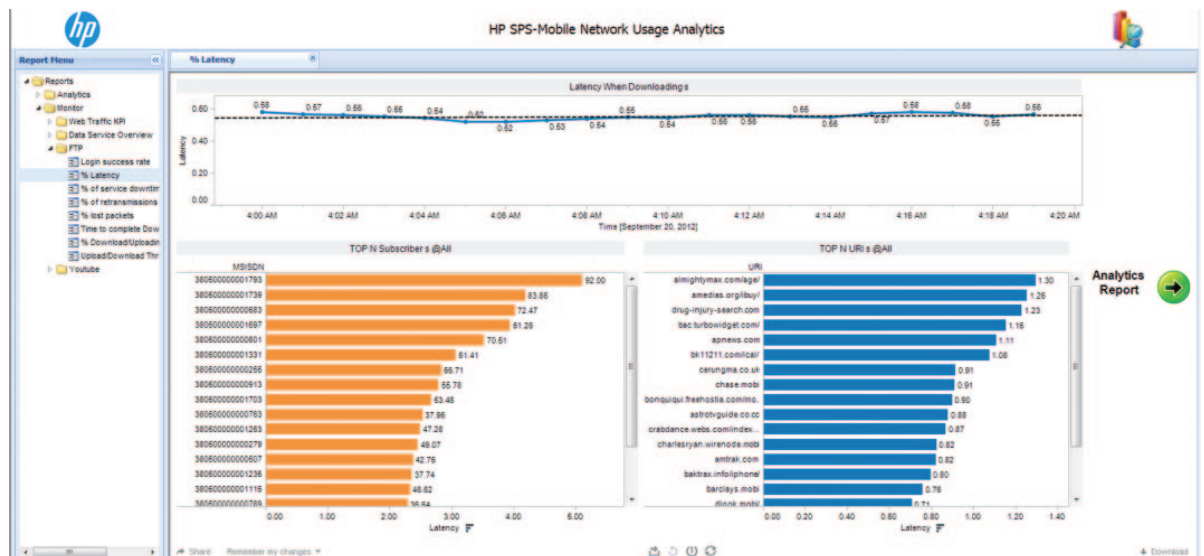
Stage 2: QoE KPI production and monitoring

The scope of HP SPS QoE engine is to provide indicators to monitor the customer experience when subscribers access and use services.

It is important to highlight that KPIs are aggregated information. They are the result of a transformation process, which starts with raw data. Raw data is initially validated, filtered, and normalized. After this phase, data is correlated with other data to enrich the original data source. Until this stage, data are still not aggregated. Last stage is the transformation of data in aggregated entities: the QoE KPI. This phase is generally done by some stages, where data are aggregated and statistically transformed.

Generally, QoE and KPi data also are shown in Web dashboard by the visualization engine. An example of the QoE KPI produced is shown in the picture below.

Figure 9. Example of QoE KPI-FTP service latency



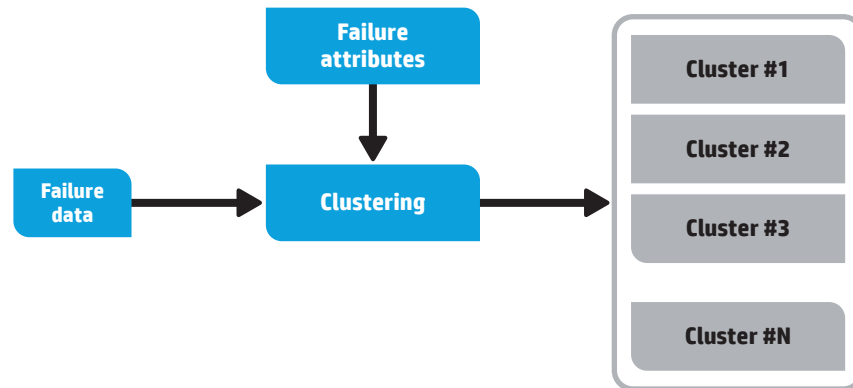
HP SPS QoE engine produces voice (3G and 4G), Internet, and application QoE KPIs.

The output of this phase is the continuous upgrade and monitoring of QoE value and QoE violation alarms.

Stage 3: Classification engine

The data output from Stages 1 and 2 is used as input in another engine: the classification engine. Scope of this engine is classifying failure events—using unsupervised clustering techniques in group by similarity.

Figure 10. Data-failure clustering



The output of this engine is clusters of failure events for all the services.

Stage 4: Associative analysis

The cluster of failure is used by associative engine. The scope of this, using associative statistical techniques, is to generate rules for understanding the failures:⁴

- Change of failure
- Attributes related to the failures (failure rules)
- Relation between attributes and specific failures type (type of failure rules)

For each of the failure clusters, the engine analyzes all the events looking for associative rules, for instance, a call drop event associated often with specific network condition, location, radio signal power, or other aspects. In other words, every failure event is composed by a set of fields—device name, firmware type, version, call drop reason, network condition, and call type. The engine looks at more probable associations among these fields. The value of the rules is measured against three aspects:

- Support or coverage (percentage of the number of events, containing both field X and Y vs. number of total events)

$$\text{sup} = \text{Pr}(X \cup Y)$$
- Confidence or accuracy (ratio of number of events, containing both X and Y vs. number of event containing X)

$$\text{conf} = \text{Pr}(Y | X)$$
- Lift or rule importance (ratio on the number of transaction, containing both X and Y vs. the product between number of transaction containing X and the one containing Y)

The best rules are the ones exceeding predefined support are called “minimum support value” and having high confidence.

The best rules discovered by HP SPS associative engine are the root-cause analysis of the failure investigated.

⁴ Associative analysis is a key data mining method used for discovery relationship between variables. One of the famous uses of associative analysis is to identify relationships between items purchased in a store. Over the years, this method has been applied to more complex data patterns such as sequence, tree, and graphs. Other training algorithms build a model that assigns incomplete items into one category or another.

Stage 5: Recommendation engine

In this phase, the HP Solution analyzes the root-cause rule produced in the previous stage to decide the best action to perform to solve the issue. This engine uses mainly collaborative filter technique, memory-based reasoning (MBR), and decision trees. These methods are based on the concept of similarity.

- Memory-based reasoning—Results are based on analogous situations in the past.
- Collaborative filtering—Results use preferences in addition to analogous situations from the past.

In general, both methods can be described as a process of solving new problems, based on the solutions of similar past problems. Memory-based reasoning or collaborative filtering tools find cases and records in a database that are similar to a specified pattern. A user specifies how strong a relationship should be to identify a case match. Software tries to measure the “distance” based on a measure of one record to other records and cluster records by similarity.

The output of recommendation engine is one or more scored actions to be executed into the network.

Conclusion

HP Smart Profile Server analytic platform brings customer experience management to a next level—moving the focus from monitoring the situation to automatic discovery of the root cause of the issues and to solve them. The combination of Big Data and advanced analytics enables automatization of the whole service assurance process.

HP SPS enables telecommunications operators to manage the increased complexity of their networks: automating the whole process of customer experience assurance, reducing costs, and increasing customer satisfaction and loyalty.

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