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User Services Platform (USP)

New Standard in Embedded and Server-Side Technology Will Transform Device Management For Traditional And Emerging Applications In The IoT Age

A Technical Paper prepared for SCTE•ISBE by

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Introduction

More than ever before in the history of the modern connected world – which includes all manner of service delivery, such as cable broadband, fixed and wireless telecommunications - the use of industry supported device provisioning and management standards is critical. There are many reasons. Among them two which must guide the decision and actions of industry and technology leaders: Traditional and new generation connected devices will soon be measured in the billions; connected devices must be securely and efficiently managed, requiring unparalleled cooperation between manufacturers and operators; and investment in the technologies required to harness the potential of the new global connected world must be protected by agreed upon standards supported by a global base of operators, technology providers and manufacturers working together to propel safe innovation to new levels.

One such standard, User Services Platform, or USP, meets these criteria, and is poised to transform device management forever. Based on Broadband Forum Technical Report 369, USP has evolved from the long and proven history and ongoing support of TR-069 and allows global introduction into customer Premise Equipment (CPE) of all types, and the operations of cable broadband and service providers of all shapes and sizes without disruption. The design and architecture of USP, indeed, allows for an equally smooth transition for manufacturers due to thr use of a common data model.

Offering a standardized architecture and protocol for the active and secure management of massive populations of connected devices, USP provides a strong utilitarian foundation for hardware-software solutions and product application ecosystems. In economic terms, this combination could be considered an Efficient Frontier, with the risk-reward tradeoffs representing technology options which have been designed into the USP specification rather than omissions based on compromise. The breadth of the USP's technology foundation, and the resulting flexibility of for operator implementation and its use for revenue generating third party applications to expand an operator's ability to safety support entire Internet of Things business verticals, represents a universal adoptability particularly important to cable operators.

Innovation based on a widely adopted and supported industry standards, moreover, has the benefit of reduced risk for invested capital, and reduced technology risk as a matter of product lifecycle management. When the resulting 'product' output of a standard is manifest in both hardware and software, gains in risk-avoidance may not be proportional to investment, but exponential in the value of the resulting solution output. Operational efficiency resulting from implementation, particularly in the absence of new technology adoption cost, moreover, supercharge beneficial outcomes; a combination of factors which can justify the use of the word transformational in a time of underserved superlatives. This kind of return on investment (ROI) that can transform companies and industries, providing a significant competitive advantage in the modern connected world marketplace. Because of the wide variety of implementation options provided by USP standardization of technology imposes no limitations of imagination, innovation and user leadership with respect to new best practices, killer applications and executional excellent among the operator and manufacturer communities.

This paper explores how the adoption of USP by cable broadband operators and equipment manufacturers can transform operational efficiency and enable the creation of new revenue streams - outcomes of contemporaneous value in operations centers and boardrooms.

User Services Platform, USP

User Services Platform has been described as the evolution of the Broadband Forum Technical Report TR-069, which defines the CPE WAN Management Protocol, or CWMP, originally created to provide service providers with a standardized protocol to remotely manage customer premise equipment (CPE) via a central software platform, an Auto-Configuration Server (ACS). The widespread adoption of TR-069 has resulted in reliable embedded protocol stacks for CPE, and as the populations of CPE managed by a single ACS continued to increase through market growth, and the consolidation of operators through mergers and acquisitions, the carrier-class ACS was developed. TR-069 has been so successful as a CPE standard in the cable, carrier and consumer marketplace its resulting protocol stack is used in over one billion devices worldwide. In the United States, CPE, including customer and business premise modems, wireless access points and a growing variety of service gateways, served a growing number of the country's 97 million broadband internet customers [1] this year, and produced more than $89 billion in operator service revenue. [2] The growing number and variety of connected devices – particularly those under management by service providers – has given rise to significant investment in device and network management technology. Broadband Forum Technical Report TR-369, widely known as User Services Platform, is a prime example. Enter, USP.

User Services Platform. USP is a standardized architecture and protocol for managing connected devices and enabling their active control through an interoperable framework based on a structure of Agents and Controllers. As an introductory reference, a USP Agent can be considered the embedded component of the architecture, and a USP Controller to be the server-side component. USP does allow, however, many functional combinations for complex operations, and the leveraging of multi-protocol device and application ecosystems. For this reason, in USP Agents and Controllers are both designed to serve as endpoints.

USP Agent. A USP Agent is an endpoint which exposes functions represented by a set of Service Elements. Service Elements are objects, parameters, events, and operations which represent certain interfaces or functions, such as performance statistics, Wi-Fi, smart home objects and others defined in the USP data model. A USP Agent is designed to receive and respond to messages from a USP Controller, or to send notifications about activity to which the Controller has subscribed. One of the design features of USP ideal for both service delivery and Internet of Things (IoT) operations is the ability to use multiple USP Controllers with an Agent (or a population of Agents embedded on similar or dissimilar CPE). This capability allows highly specialized applications to be designed and deployed for specific operations. These specific operations can serve operationally relevant functions for customer care, Wi-Fi management or performance monitoring.

A USP Agent can also represent Service Elements on a device directly, or via proxy. An Agent is not restricted to represent only Service Elements contained within the same platform as itself. This is a significant and potentially empowering feature of USP, worth repeating. A USP Agent is not restricted to represent only those Service Elements contained within the same platform as itself. Consider the number of connected devices and multitude of communications protocols within the average home (and on the shelves of consumer electronics stores) to envision the possibilities. Systems which communicate via a protocol other than USP, such as Thread, or via another system bus, can be represented by the USP data model's device proxy mechanism. The data model's "ProxiedDevice" table populates with elements that can be hosted on other devices - such as IoT components - and allows a Controller to use USP to manage, monitor, and control them.

USP Controller. A USP Controller is an endpoint which allows users and applications to manipulate the functions exposed by an Agent. In USP, the functions exposed by the Agent are those defined by the data

model, which will often be referred to as TR-181, or Device:2, because of its history as the data model for TR-069. One of the benefits of USP, indeed, is the use of a robust and vetted data model which has been used in the marketplace for over a decade, and which has evolved with the needs of the broadband community. The inclusion of the TR-069 data model in the USP architecture is one of the factors beneficial to the implementation of USP in the market because a common data model can be managed by an ACS or a USP Controller, or both. This not only allows operators to preserve the investment made in ACS and related technology already providing valuable provisioning functions in CPE operations, it also recognizes that many of the operations performed by an enterprise-class ACS will continue, eliminating the costly disruptions which can accompany new technology rollout. A recommended rollout plan for USP would likely include the continued use of an ACS and TR-069 for provisioning, and the adoption of a USP Controller for specific applications, such as mass data collection, which can be implemented more efficiently with a TR-0369 agent. Unlike other device management architectures, there is no single capstone Controller; the requirements of the operator dictate Controller operations.

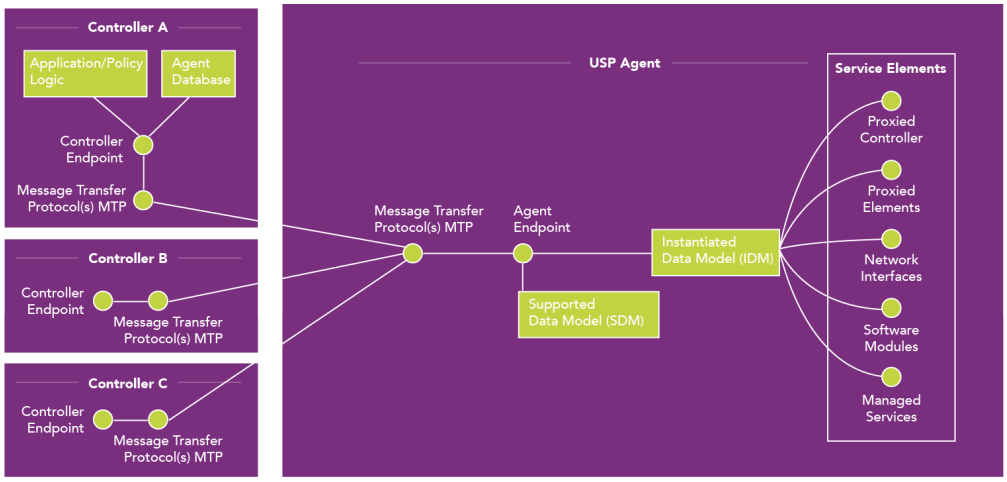

Figure 1 - USP Agent, Controller and Service Element Relationship

Embedded USP Agent Strategies

As with any industry supported technology the availability of USP Agents to the CPE manufacturing community will allow for mass implementation in the production phase, the same as current standard processes for operating systems and firmware packages. Operators who have in recent years become involved in the development of specifications for Set Top Boxes (STB), gateways and other CPE now have one more option for embedding a multipurpose agent capable of utilizing a variety of Message Transport Protocols, or MTPs. This variety of MTPs is one of the advantages offered by USP. Unlike a traditional TR-069 protocol stack, a USP Agent is characterized by the placement of optional operations and events into the data model, redcuing the need for unnecessary periodic remote procedure calls (RPCs). This allows reduced controller-agent communications because commands and events always operate on associated objects.

Because of the unique overall architecture of USP, implementation and integration services have become important to third party application developers in service industries, such as security and other IoT verticals, because any business or consumer grade CPE with an embedded USP Agent can become can application enabling device. Entirely new service business can emerge, therefore, though application design by companies whose solutions utilize commercially available hardware. Given this potential, it is not inconceivable to imagine a Silicon Valley startup creating a consumer friendly application for mass market

consumer products utilizing USP Agent and Controller interaction while a cable broadband operator to whose network the devices are connected might utilize a dedicated USP Controller to monitor or manage the performance of the CPE. Given the experiences of some operators experimenting in the IoT service offerings, this scenario can be very compelling.

USP Controller Strategies

While USP Controllers can be deployed for a wide variety of operations involving CPE with USP Agents for dual TR-069 and TR-369 stacks, they are not likely to replace the ACS for core provisioning functions. A reasonable strategy for use of USP Controllers would entail bridging the gap between already deployed and new technology. Where USP dual-stack Agents are embedded in CPE operators can evaluate the introduction of USP Controller capabilities alongside existing ACS operations, utilizing USP Controllers for operations requiring highly secure Message Transport Transport Protocols such as Websocket, or lightweight messaging with MQTT. This strategy allows for the introduction of the powerful USP Controller capabilities while maintaining efficient use of ACS operations for CPE provisioning.

Because there is no single 'ideal' USP Controller function, operators are unrestricted in their input to USP Controller developers to address their most operationally exigent requirements, or to develop IoT ecosystems for revenue generation. In the case of creating operational tools utilizing USP Controllers, operators have extremely powerful features at their disposal, such as the ability to use multiple Transfer and Transport Protocols. The protocol agnosticism of USP, indeed, is one of its most flexible attributes.

USP Architecture and Design Considerations

Multiple Transport

USP provides clear definition of protocol and transport, referred to in the Technical Report as Message Transfer Protocols, or MTPs. One benefit of this well-defined structure is assurance protocol will operate the same way regardless of the transport used. A related benefit is that with the support in USP of multiple transport protocols additional protocols can be added in the future and industry and user needs evolve. The inclusion of multiple transport capabilities in USP means operators, application developers and integrators can use different transport based on specific use-cases. As significant, multiple transport can be employed using the same USP Agent. The following MTPs are supported in USP at the time of tis writing:

WebSocket. A transport for point-to-point legacy devices as an option to HTTP and frequent communication.

STOMP. A form of message broker transport protocol designed for cloud controllers supporting LAN-side devices, and devices which might move from one network to another.

MQTT. A machine-to-machine (M2M) connectivity protocol associated in recent years with IoT applications. MQTT is designed as a lightweight publish/subscribe messaging transport known for its small size, low power usage and minimized data packets.

CoAP. Constrained Application Protocol is a specialized web transfer protocol for use with constrained nodes and networks designed for use in IoT applications. Also an M2M protocol, CoAP is sometimes associated with smart energy and building automation applications.

In addition to these transports, USP defines an out-of-band mechanism for collecting large amounts of bulk data in JSON or CSV format over HTTP. Specified for both TR-069 and TR-369, this is known as the "HTTP bulk data collection mechanism" and is included in an annex of both specifications.

USP Security

The security of massive networks of connected devices is a topic of importance to any operator, and certainly those in the cable broadband industry whose networks are fueling the rapid growth of the connected home. With USP the Message Transfer Protocol (MTP) must use secure transport when USP messages cross internetwork boundaries. It may not be necessary in some cases to use MTP layer security for messages within an end-user local area network (LAN), but it is necessary to secure transport to and from the Internet. Devices utilizing a USP Agent and Controller architecture are sure to support encryption of all MTP protocols. Two common examples are:

- MTPs which operate over UDP will be expected to implement DTLS 1.2 (or greater as updated from time to time by RFC standards)
- MTPs which operate over TCP will be expected to implement TLS 1.2 (or greater as updated from time to time by RFC standards)

USP Data Model

The figure below displays the USP data model. As mentioned earlier, the data model includes many features of the proven TR-069 data model. In the context of the USP architecture, there are other powerful considerations in its application.

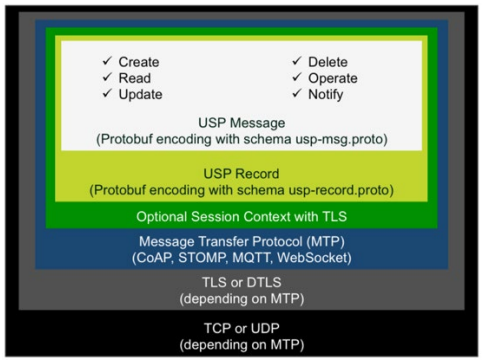

Figure 2 - USP Data Model

Extensive data type and restrictions-support are included. The data model specification used in USP defines a wide variety of numeric, textual and binary datatypes for use with parameters in the data model. A rich set of annotation for documentation or tool usage (e.g. description, units, default value, status and version), as well as a comprehensive set of attributes which can be placed on a parameter to restrict its use (e.g. write- and read-abilty, ranges, patterns, enumerations, references), represent significant advances.

Extensive tooling for the data model provides development and lifecycle support. In Technical Report 369 and related specifications, the Broadband Forum BBF provides a comprehensive set of standardized and frequently updated data models. Well maintained tooling for conversion, documentation and

verification of the raw data models, and organized membership participation in testing, ensures interoperability and consistent documentation of implementations.

Introspection of the supported and instantiated data model is a powerful factor to ongoing viability. USP supports a GetSupportedDM message which allows a USP Controller to introspect the supported data model of a USP Agent. By using this message, a Controller can learn about the supported objects and parameters, and the operations allowed to be used on them, the data model defined commands and defined event types a USP Controller can subscribe to for notifications.

Encoding of custom operations and events, including input/out arguments, in the data model add to the extensibility and introspection features. Different from TR-069, which utilizes a pre-defined set of mandatory and optional RPCs for specialized operations (e.g. software download, and reboot), USP defines a mandatory set of messages, and has moved all optional operations and events into the data model. This allows for a vastly improved flexibility, reduced implementation and extensions because commands and events always operate on associated objects.

Operator Services Enabled by USP

Given the variety of implementstion options provided by USP it is clear one of the benefits os USP is, in fact, its almost endless possible operator services. At the time of this writing there are several noteworthy areas of focus by early adopters. Several of these operator service features are provided here.

Performance Measurement and Diagnostics. The USP data model allows a Controller to initiate download and upload performance operations, obtain network mapping and performance diagnostics.

Management and Monitoring of Critical Network Interfaces. USP contains elements for managing and gathering statistics from a device's entire network stack, including physical interfaces (Ethernet, Wi-Fi, Zigbee, etc.), SSID and MAC layer information, IPv6 interfaces, DHCP, tunneling, and more. These components are connected and read via an Interface Stack object defined in USP which describes the active connections of a subject device.

Management and Monitoring Network Services and Clients. USP exposes elements for managing access to network and security services, including firewall, DNS, network time (NTP), QoS, routing policies, connected hosts, and user access. An application layer, moreover, connection interface such as MQTT, XMPP, or STOMP can also be enabled.

Management of Containers and Applications. USP allows users to install, monitor, and manage the lifecycle of execution containers and software modules via the USP Agent, using objects, parameters, and operations built into the data model.

Machine Learning and the use of Optimization Algorithms with Real-time Telemetry. USP mass data collection allows for the aggregation and delivery of data to a machine learning or AI endpoint. Through a USP management channel users can be provided control over which data points are be gathered and delivered to analysis resources, making USP ideal for always-on performance data collection and analysis.

Ongoing evolution. Important to operators, manufacturers and technology providers adopting USP and participating in the ongoing evolution of if it and related standards, new features and elements

can be added to the data model through collaboration and iterative work through Broadband Forum. New releases of the data model are produced numerous times per year.

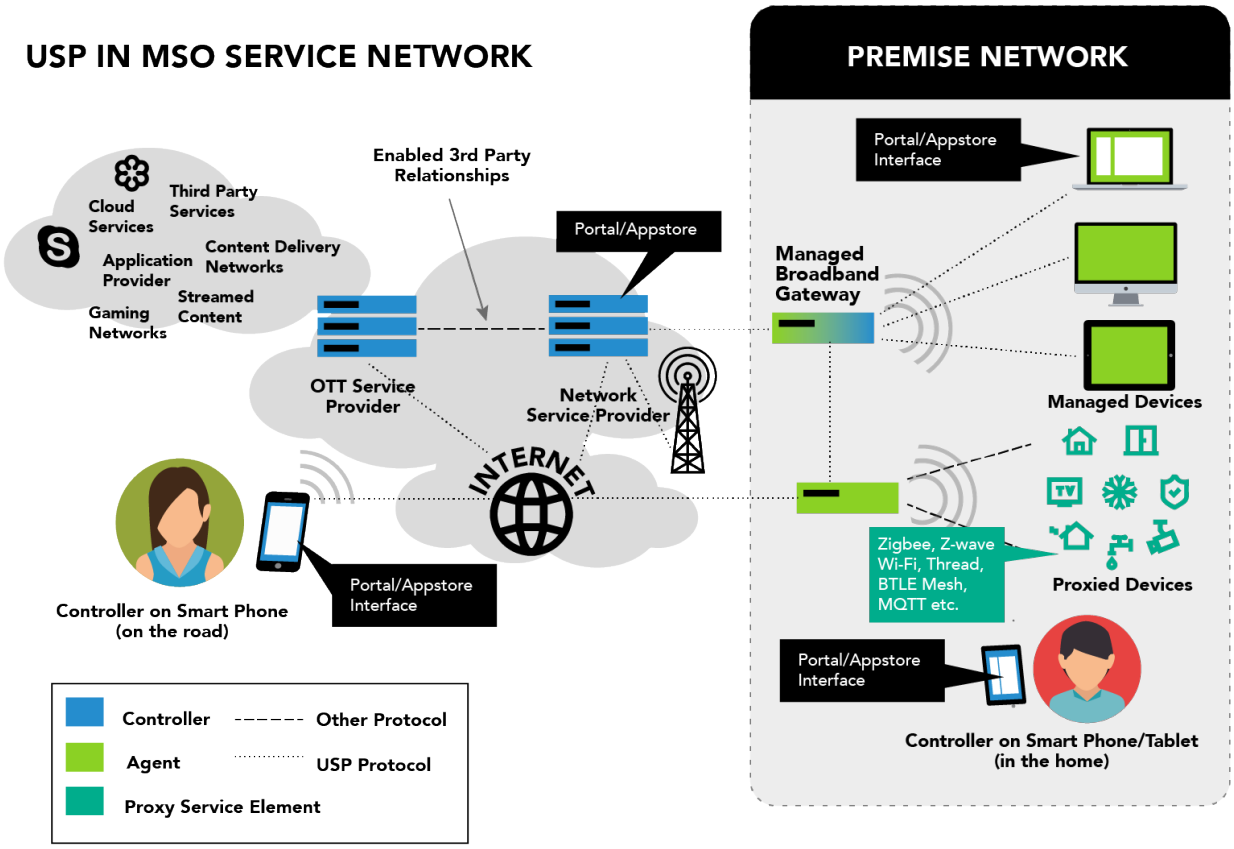

Figure 3 - USP in MSO Service Network

Operator and Industry Use Cases Employing USP

As described the definition of USP and its architecture, a wide variety of use cases are enabled by the standard. Because USP has been developed out of an evolutionary process beginning with TR-069, now used in over one billion devices, and with the base of industry experience this widespread acceptance implies, the use cases for USP are numerous. The following are several relevant to the cable broadband industry.

Mass Collection of Performance Data. USP allows operators, equipment manufacturers and third-party applications developers to develop applications which gather mass telemetry for analysis, machine learning and performance optimization.

Customer Self Care Applications. USP Controllers can be designed for end-user devices to allow customer self care portals without dependence on cloud resources. Utilizing USP for this type of application, moreover, allows operators to either design customer self care applications themselves,

collaborate with manufacturers, or utilize the expertise of industry software companies providing USP and ACS operations to cable operators and carriers.

Standardized Onboarding and Management of IoT Devices. USP is ideal to unify the wide variety of IoT, smart home devices and emerging connected devices by proxying non-IP protocols such as Thread, Zigbee, Z-Wave, and others, under the management of one comprehensive architecture which is also incredibly flexible and well suited for myriad real-world applications. Using USP operators, manufacturers and third-party application-driven businesses can work together, collaborate and innovate.

Managing a Smart Home. With the evolution of smart home devices and their capabilities, the consumer marketplace contains a who's-who of vendors focusing on a variety of modern smart home applications. For example, DIY security, smart home lighting, intelligent climate control, smart appliances and others proliferate the marketplace. The multitude of devices and their own proprietary frameworks mean end customers can face a daunting task integrating the best features or attributes from different manufacturers. USP can help not only manufacturers and applications developers standardize a development framework, but they can adopt one useful for operators to help maintain optimal performance once they are connected to a service provider terminal.

Smart Wi-Fi Management. USP can provide the capability for customers to manage their on-premise router prioritization to favor gaming, streaming or browsing traffic based on data collected from connected devices. While also useful to operators who wish to interact at this level, customer self-allocation can provide the best of both worlds – operator access and end-user self-prioritization. The customer can review their own usage data in real time and take a decision to execute a prioritization policy, reducing CSR calls, or at least reducing their duration. Consumer education, moreover, supports the viability of this option now more than ever before.

Accelerated Development of 'Insanely Great' Products and Services. Many of us remember the famous line from one of Steve Job's Apple keynotes. In a world of incredibly utilitarian and robust open standards, insanely great products for worldwide mass adoption could certainly benefit from standardization. Product development of IoT hardware and applications is a prime example. A recent study found that 70% of IoT start-ups fail. In addition to protocol fragmentation, IoT businesses also face cloud management fragmentation, and new hardware technologies appear and disappear like confetti. USP offers a common technology architecture to address IoT biggest challenges.

Protection of End-user Data in IoT. It will be no surprise to anyone reading this paper that many of the 'successful' mass market IoT applications send a lot of personal data to service companies whose revenues, individually, exceed the Gross Domestic Product of first world economies. With USP, those companies need not peek at, collect or exploit user data. Complete IoT service application ecosystems can be developed using USP Agents and Controllers and the secure messaging protocols described above, while still providing performance troubleshooting and support access to network service providers.

Conclusion

User Services Platform, or USP, provides operators, manufacturers, technology providers, and enterprising applications developers the ability to make dramatic advances in device performance, management and functionality without abandoning currently deployed assets, disrupting current operations, or making hopeful investment decisions on proprietary technology. When a new industry-supported technology

advances the most purposeful business objectives of so many interdependent participants of an industry attention must be paid, and adoption must move forward.

Abbreviations

ACS	Auto Configuration Server
AP	access point
BPS	bits per second
BBF	Broadband Forum
CoAP	constrained application protocol
EI	endpoint identifier (ID)
HTTP	hypertext transfer protocol
IoT	Internet of Things
MQTT	MQ telemetry transport
MSO	multisystem operator
MTP	message transfer protocols
ISBE	International Society of Broadband Experts
RPC	Remote procedure call
SCTE	Society of Cable Telecommunications Engineers
SEP	service endpoint
STOMP	simple (or streaming) text orientated messaging protocol
USP	User Services Platform, TR-369
STB	set top box
TR	technical report, abbreviation used by Broadband Forum

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