TALQ Specification Overview

TALQ Technical Working Group

March 2015

References

[1] TALQ Consortium http://www.talq-consortium.org/
[2] RFC 2616 - Hypertext Transfer Protocol -- HTTP/1.1 (http://www.tools.ietf.org/html/rfc2616)
[3] RFC 2818 - HTTP Over TLS (http://tools.ietf.org/html/rfc2818).

1. INTRODUCTION

The TALQ Specification defines the application protocol between a Central Management System (CMS) and Outdoor Lighting Networks (OLNs) to enable configuration management, lighting control and monitoring of outdoor lighting systems.

The objective of this white paper is to provide an overview of the scope, basic concepts, system architecture, data models and functionalities adopted in the TALQ Specification. The latest approved TALQ Specification is version 1.0.1.

2. TALQ Architecture and Protocol Stack

The TALQ Specification defines an application layer protocol according to the OSI reference stack including the message types, data format, parameters and behavior of the application end-points at the OLN side (called TALQ Bridge) and at the CMS, as illustrated in Figure 1.

One of the design principles adopted is to leverage existing industry standard protocols as much as possible in order to focus mainly on the lighting application aspects. As such, the TALQ Application Protocol relies on underlying data transport and network layer services to establish communication between the TALQ end points. The top layer defines a set of messages, data types and elements needed to model resources, functions and services to support the lighting application requirements. All the application data is encoded in XML and transported over an application messaging layer based on HTTP (HyperText Transfer Protocol) [2]. The application support messaging (HTTP), transport and network layers are considered as part of a reference protocol stack and thus specified for compliance testing.

A variety of data link and physical layers protocols may be used in providing a complete solution. Generally, data link and physical layer protocols are outside the scope of the TALQ Specification, and are left as vendor implementation specific. In other words, the TALQ Specification is independent of the underlying connectivity layers and TALQ end points should be able to communicate over any physical media (i.e. wireless or wired connectivity options may be used) as long as the necessary transport and network layer services can be established.

The TALQ Application protocol follows a client-server architecture, in which the CMS is the Server that hosts resources, and the TALQ Bridge is a Client that updates statuses and attributes in the CMS, receives commands and requests from the CMS and passes them to the OLN for execution of the corresponding actions. In this model, the CMS (Server) may also asynchronously send resource updates and commands to the TALQ Bridge (Client). On the

other hand, the TALQ Bridge is in control of specific entities as well as the implementation of actions within the OLN.

The TALQ Specification also describes the mechanisms to secure the transactions between the TALQ application end points, which are based on well-known HTTP over TLS (Transport Layer Security) [3].

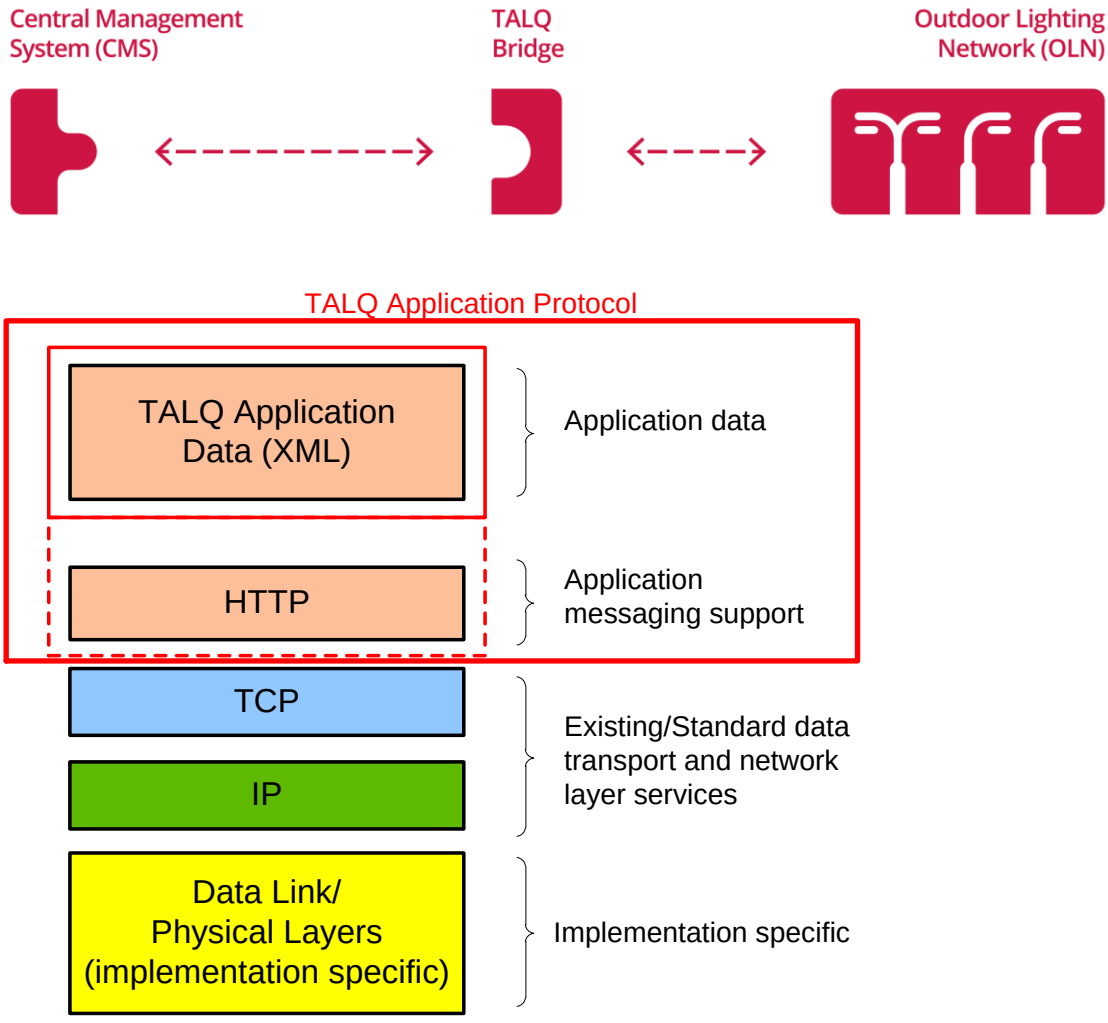

Figure 1: TALQ Specification and Reference Protocol Stack

3. TALQ Data Model

The TALQ Specification adopts a data model in which the system resources and associated functionalities are grouped in functions within logical devices (e.g. lighting actuation, metering, and sensing).

A TALQ logical device is a logical representation of a device, which implements one or more TALQ functions. A TALQ function consists of sets of attributes and events, which describe and support a certain functionality. For instance, a logical device modeling a luminaire controller may include lighting control, monitoring and metering related functions.

Figure 2 illustrates the concepts and relationships between a physical device, functions and a logical device. It should be noted that a logical device may implement one or more functions, multiple logical devices may be implemented in a single physical device, and multiple physical devices may be modeled as one logical device.

A TALQ function consists of a group of attributes and events that describes a functionality of a logical device. Some of the TALQ functions include: Basic, Communication, Lamp Actuator, Lamp Monitor, Electrical Meter, Photocell, Time functions.

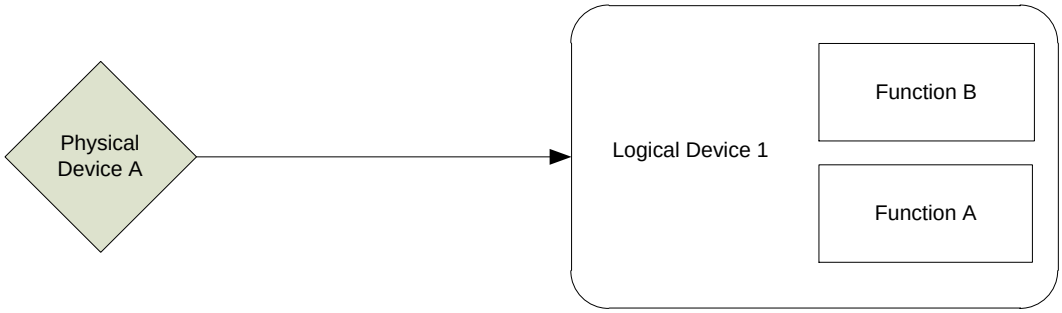

Figure 2: Logical Devices and Function Sets

In general, logical devices can be used to model physical devices that are individually managed within the OLN. Typical logical devices include luminaire controller, cabinet controller, electrical meter, communication gateway.
Figure 3 illustrates examples of logical devices that may correspond to physical devices and some of the supported TALQ functions. The TALQ Specification does not restrict the implementations of logical devices, nor mandates any hardware or physical implementation of the logical entities described in the specification.

Logical device are uniquely identified by a TALQ address, which consists of a domain address (dev is the domain address for logical devices) and an entity address. Specific functions and attributes can also be accessed using the TALQ address. For instance, an attribute within a function in a logical device can be accessed as follows:

dev:<dev-address>[:<function id>[:<attribute id>]]

The *function id* in the above example is an identifier of a particular instance of a function within a logical devices. The *attribute id* is specified for every function attribute in the TALQ Specification.

In addition to logical devices and functions, the TALQ Specification also defines services (Section 4) that enable operations on the logical data model (i.e. logical devices and functions) to implement well-defined features, such as system configuration, lighting control, data collection, and group management.

The TALQ data model provides the basis to enable easy adoption by CMS and OLN manufacturers/vendors whilst leaving the model open to accommodate possible future extensions.

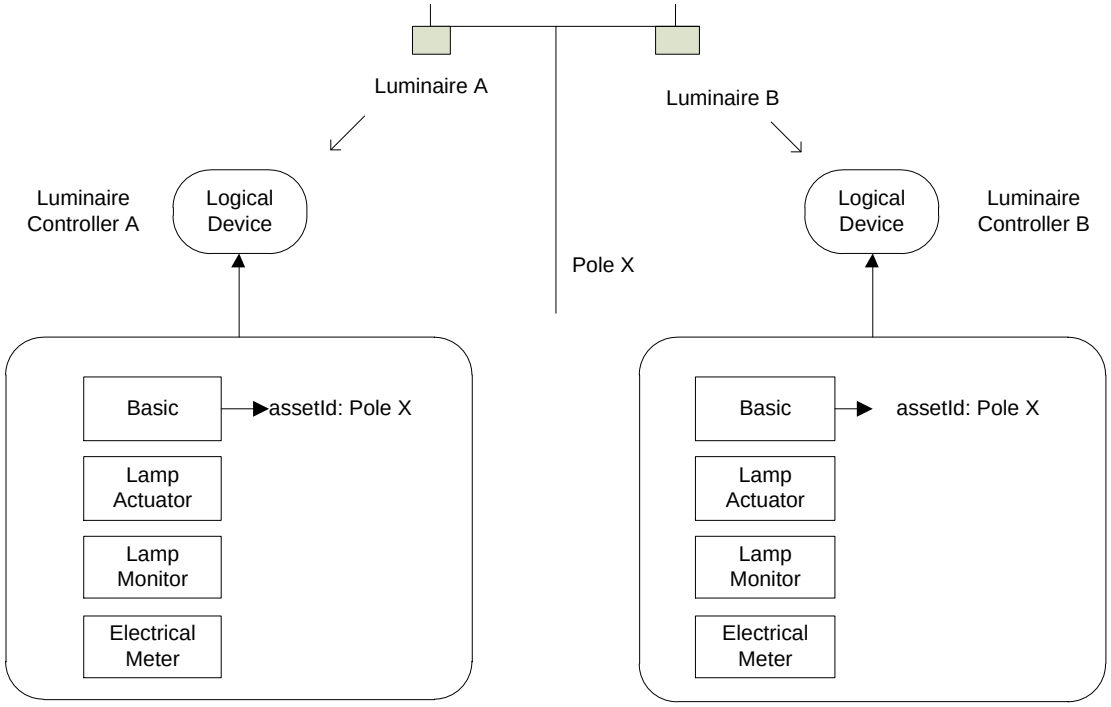

Figure 3: Example of Logical Devices and Functions.

4. TALQ Services

The TALQ Services define the message exchanges and application behavior needed to manipulate function attributes in order to implement a certain feature. The following services are supported:

- Notification Service: defines the messages to support asynchronous CMS to TALQ Bridge communication using the HTTP protocol;
- Configuration Service: defines the process of configuring and managing system capabilities including bootstrapping of the application end points, discovery of devices and device configuration updates;
- Lighting Control Service: defines the lighting control features supported, such as scheduled controls and manual override;
- Data Collection Service: provides features to efficiently collect and transfer data from the OLN to the CMS;
- On Demand Data Request Service: provides a request and response mechanism to enable access to operational, measurement and status information of logical devices in the OLN on demand;
- Group Management Service: provides mechanisms to define and manage groups of logical devices and functions within logical devices;
- Data Package Transfer Service: provides a mechanism to transfer data packages containing OLN vendor specific information to the TALQ Bridge via the CMS.

The Notification and Configuration services are basic services required to initialize and configure the system and therefore are mandatory for both CMS and TALQ Bridges.

The Lighting Control, On Demand Data Request and Group Management Services enables the implementation several remote lighting control and management use cases.

With the TALQ Services and the definition of logical devices and functions, the TALQ Specification enables key features including

- System configuration and upgrades;
- Multi-level lighting control;
- System monitoring, and measurements.

5. Key Features

The previous sections described the basic building blocks of the TALQ Specification including system architecture, protocols, logical entities, functions and services. This section provides a few examples of how these building blocks support key features in the TALQ Specification.

5.1 System configuration and upgrades

The configuration of an outdoor lighting system using the TALQ Application Protocol consists of two main steps. Firstly, the device implementing the TALQ Bridge function, which represents

the TALQ end point at the outdoor system side, performs a bootstrapping procedure in which it establishes a secure connection with the TALQ CMS, receives a TALQ address and exchange all required configuration information to start operation as a TALQ Bridge. No operational message exchanges are allowed until the TALQ Bridge successfully complete its bootstrapping process. The second step is the discovery by the CMS of the TALQ Services, and logical devices supported by the OLN via the TALQ Bridge as well as the configuration of all logical device properties.

After these two steps, the CMS should have complete information about the OLN and the TALQ Bridge and other logical devices should be properly configured and ready to initiate the normal operation.

All required configuration messages and procedures are provided by the TALQ Configuration Service. The configuration of devices is performed by updating the configuration parameters in the TALQ functions implemented by the devices. The TALQ Bridge bootstrapping is a onetime procedure, but configuration messages can still be used during normal operations by both TALQ Bridge and CMS to announce and execute configuration changes.

5.2 Multi-level Lighting Control

Lighting control is a core capability in a lighting system and it is supported by the Lighting Control Service, which defines the mechanisms to operate the lamp actuator function in order to enable schedule based and override control. The override control enables the CMS to actuate any connected lamp actuator or groups of lamp actuators. Figure 4 illustrates the message exchanges to deliver the override control command from the CMS to the TALQ Bridge. The TALQ Specification defines a standard exchange between the CMS and TALQ Bridge to deliver the control commend and obtain a notification of receipt. However, the implementation of the specific control action within the OLN is outside of the scope of the TALQ protocol.

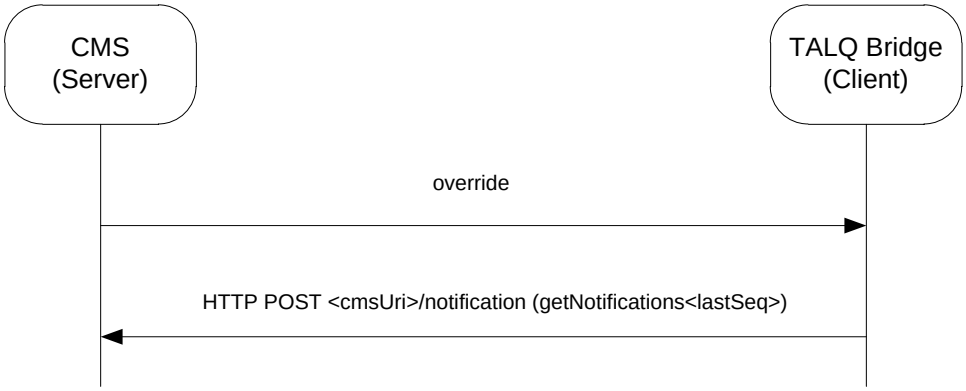

Figure 4: Message exchange for a control override.

The schedule based control enables the CMS to pre-configure the behavior of one or more lamp actuators based on several factors, such as time and sensor inputs. The TALQ Specification introduces the concepts of Control Program and Calendar to enable interoperability on the configuration and execution of schedule based control across systems.

A TALQ control program is a generic mechanism, or template, to automate the control of a lighting system within a day. In other words, a control program is a combination of control actions and trigger conditions that define the lighting control behavior, which can be applied to one or more lamp actuators across OLNs. A calendar is a set of rules that describe which days and which control program should be applied to which target lamp actuator(s).

The TALQ Specification defines standard formats and rules to flexibly create and deploy calendars and control programs. For instance, a user should be able to define a calendar that applies a control program named "MyControlProgram1" to a given lamp actuator every day in the year, except in the time frame from 25th of July to 16th of October when another control program named “MyControlProgram2" should apply. The user could also define a third control program called "MyControlProgram3" to apply every Saturday and Sunday throughout the year.

The concept of control program is very flexible and can combine different trigger events, which may be based on fixed times or other dynamic conditions, as well as external inputs. Figure 5 illustrates an example control program in which combination of astronomical clock and photo cell defines the when the lights should be on and off. In addition, dimming is applied at fixed times (fixed time control) and based on dynamic trigger events (traffic increase/decrease in this case), which may be implemented using any external data input or sensors.

The control of groups is enabled by using the messages, addressing and management mechanisms provided by the Group Management Service.

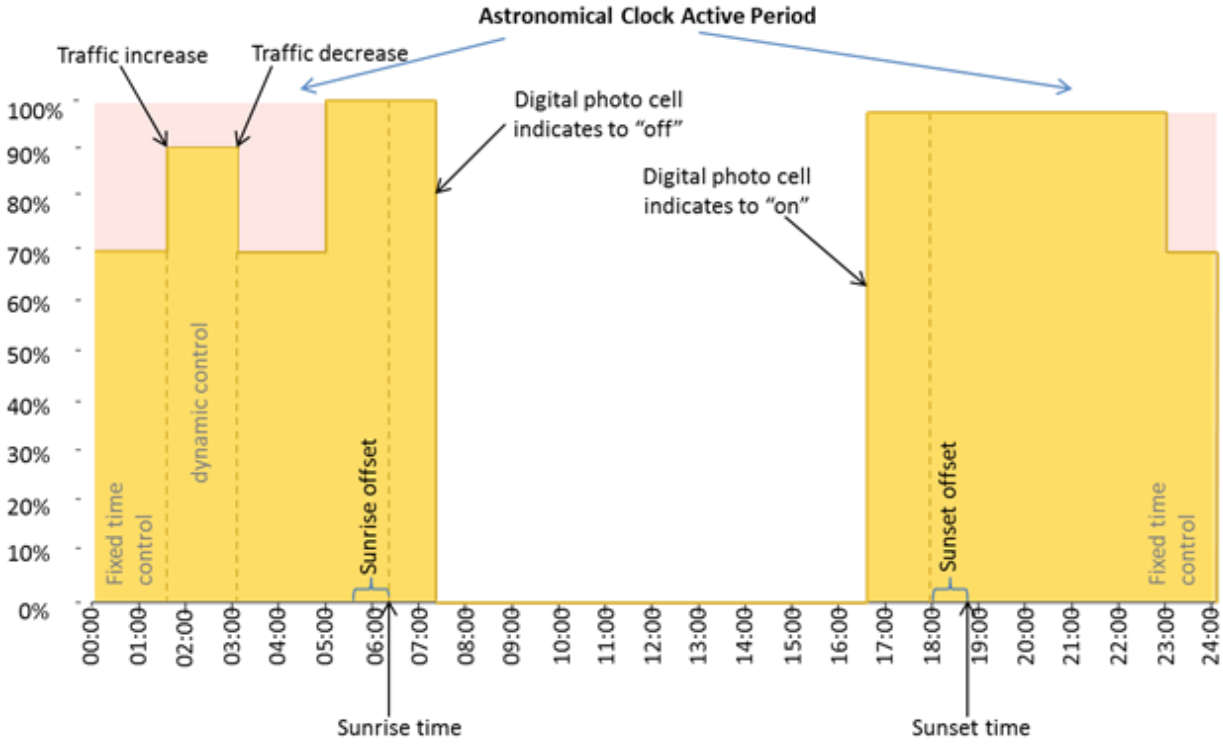

Figure 5: Example of a control program including fixed and dynamic control triggers.

5.4 System Monitoring and Measurements

Remotely monitoring the system's operation conditions through measurements is another key feature supported by the TALQ Application Protocol. Firstly, measurements of device parameters and performance is supported by measurement attributes defined in several TALQ functions. For instance, the lamp monitor function includes a wide range of measurement attributes to track the device's operation (switchOnCounter and OperatingHours) as well as electrical properties, such as supply power, voltage, current, power factor, and others. Similarly, the electrical meter function supports electrical metering capabilities including measurements of voltage, current, power, energy, and power factor. This function may be associated with Luminaire Controllers, Cabinet Controllers or electrical meters installed in switch boxes. The TALQ specification has defined all electrical meter parameters for both single as well as three phase electrical meter applications.

In addition to specific device measurements, the TALQ Application Protocol introduces the concept of TALQ events to facilitate system management and diagnosis. Events provide information about a certain situation or condition beyond a single measurement that are useful when managing the OLNs. Events may be specific to a given function within a logical device, or generic that applies to a device. For instance, the lamp monitor function may

generate an function specific event when the lamp power is above certain configurable threshold. Examples of generic events include device malfunction, invalid address and invalid configuration.

Both measurements and events need to be logged and reported to the CMS, which is supported by the Data Collection Service and the On Demand Data Service.

The Data Collection Service is a provision to configure how OLN measurements and events are logged, and when or under what conditions the logged data is transferred to the CMS. This service enables adaptation of the data collection and transporting behavior to the needs of the specific CMS and OLN implementations. It also enables aggregate information to be reported to the CMS, which can result in more efficient use of bandwidth.

The TALQ Specification does not specify how OLN devices shall carry out measurements nor how they should communicate the sampled measurements and status attributes to the TALQ Bridge. However, the Data Collection Service defines data loggers for recording of data from the OLN and reporting of this recorded data to the CMS. It is the responsibility of the TALQ Bridge to ensure the relevant attributes and events are logged and reported accordingly.

Two recording and reporting modes are supported. Period and event recording modes allow for measurements to be logged based on specific timing and events, respectively. For instance, an electrical meter function may be configured to periodically log energy consumption and other electrical measurements. On the other hand, events can be logged when they happen by using the event recording mode.

Data loggers can be configured to report back the logs to the CMS periodically or immediately after a change in the data log. In the immediate reporting mode, a delay parameter can be specified to prevent sending multiple small messages when several entries are recorded at almost the same time.

In addition to configuring data loggers, the CMS may request any set of operational, measurement and status attributes at any time using the on demand data service, which provides the mechanism to access attributes in the logical devices by requesting attribute values from the OLN.
Figure 6 illustrates the message exchange for the CMS to request data from the TALQ Bridge on demand.

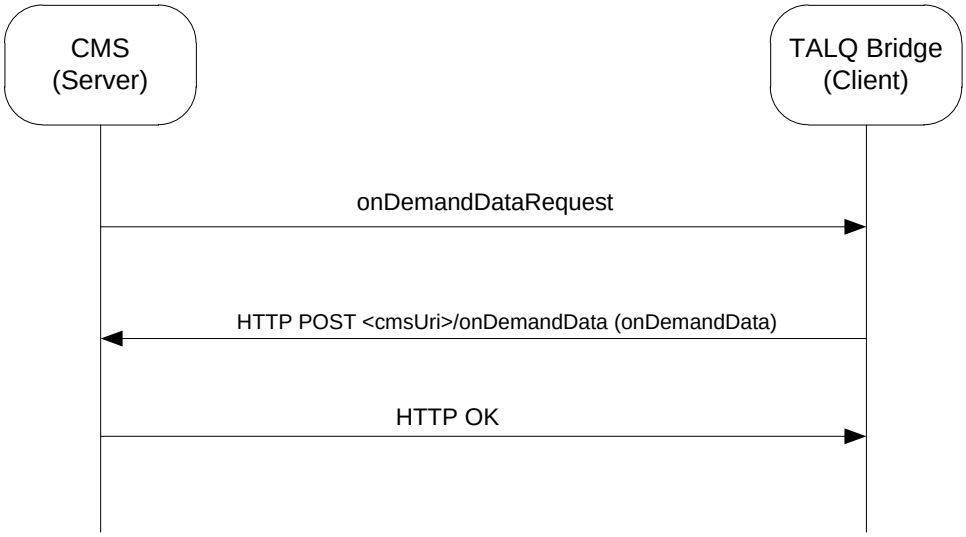

Figure 6: Example of on demand data request initiated by the CMS.

5.5 Feature classification

In order to enable interoperability across OLN implementations, the TALQ Specification defines mandatory and optional features. However, it also enables differentiation through vendor specific features.

Mandatory and optional features (attributes, events and services) are defined for each end point of the application (i.e. TALQ Bridge and CMS). Vendors can make their own choices from the optional functionality specified in TALQ and they are also able to add own unique functionality.
CMS and TALQ Bridge implementations must accept optional attributes and vendor specific attributes/events (i.e. not trigger an error when receiving such attributes/events), but they are not required to implement corresponding functionality. Figure 7 provides examples of the three categories of features in the TALQ Specification.

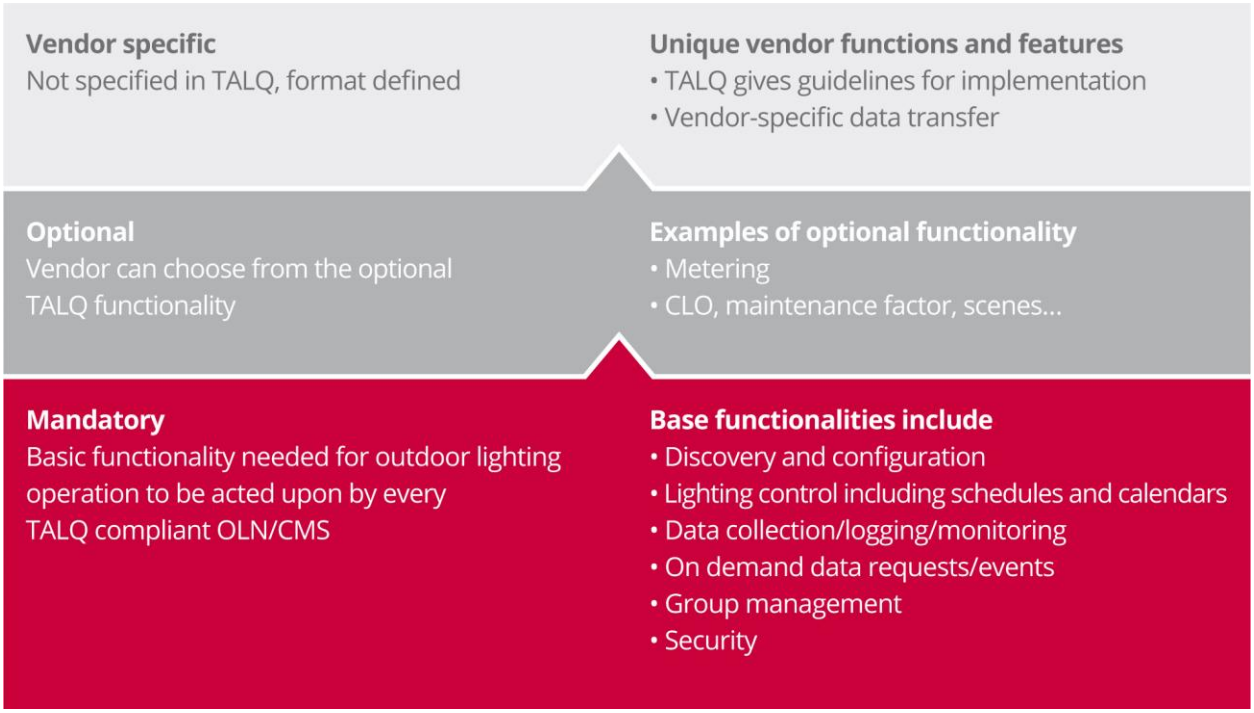

Figure 7: Examples of mandatory, optional and vendor specific features.

6. Conclusions

The TALQ Consortium has completed its first specification in the summer of 2013, which defines the application protocol for configuration, management, control and monitoring of outdoor lighting networks. The TALQ Specification was completed with the contributions of many member companies worldwide with extensive experience and know-how in designing, deploying and managing outdoor lighting networks across the globe. As such, the TALQ Specification includes a complete set of features necessary to operate and manage OLNs with different architectures, technologies and capabilities. The specification supports a complete list of use cases identified by the industry and customers. This work is expected to accelerate the deployment of outdoor lighting control systems. With TALQ, various suppliers of outdoor lighting control systems can be easily integrated with a compliant CMS. Furthermore, a customer can have a single CMS to manage OLNs from multiple vendors. The TALQ Specification focus on the minimal levels of interoperability required to meet customer needs, while allowing the industry to differentiate on deployment, operation, and management of OLNs and CMS implementations. This white paper provided a brief overview of the basic concepts and design principles adopted in the TALQ Specification. The TALQ Consortium will create and manage a certification program to test compliance with the TALQ Specification.