Design of a Performance Measurements Platform in Lightweight M2M for Internet of Things

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***Abstract*—Internet of Things is a concept where all kinds of devices can communicate with each other and the devices can provide various types of information from different locations. This kind of network provides potential new services to be offered to the end users. However, the devices are typically constrained devices with e.g. limited battery life. These set new kinds of requirements for the communication when compared to traditional networks.**

Introducing IoT Networks brings up the need of a performance measurement schema that provides the necessary information to measure and to understand the network performance problems.

We introduce a novel design, where the entities of a traditional network measurement platform, namely Measurement Agent (MA), Controller, and Collector, can be adapted to the Lightweight Machine to Machine (LWM2M) architecture in Capillary Networks. In our design, the MA is collocated with the LWM2M Client, the Controller and the Collector are collocated with the LWM2M Proxy. We use IPSO Objects to model the measurement metrics.

Keywords*—*IoT, platform, measurements, LWM2M

I. Introduction

Internet of Things (IoT) refers a concept where devices are connected to each other, sending information from their environment, and delivering this information to the Internet through a gateway. The devices have typically certain limiting characteristics, such as power and memory. Considering the anticipated massive deployment of IoT, we have to carefully take into account the scalability of the network. Early measurements are necessary to evaluate the impact of the resulting traffic on the current networks and services.

This research covers the execution of performance measurements, within a context which includes Open Mobile Alliance Lightweight Machine to Machine (OMA LWM2M) protocol [1] in Capillary Networks. Capillary Networks are composed of devices connected generally to a constrained gateway (capillary gateway) [2].

LWM2M is a device management protocol with a client-server architecture. LWM2M defines a data model where data sources are represented by resources. A resource is an atomic piece of information that can have multiple instances. A resource can be read, written, or executed. Multiple resources are logically grouped into an Object and a LWM2M Client has one or more Object Instances. These resources are fixed. In opposite, IP Smart Object (IPSO) Alliance [3] allows to reuse the resources of the objects. IPSO Objects can be used in protocols such as CoAP and HTTP. IPSO defined composite objects (an object is linked to another object) [4].

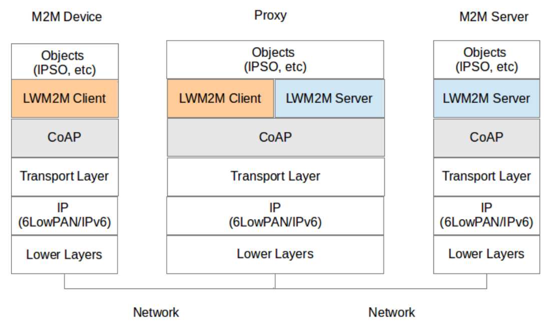

Figure 1. LWM2M Proxy Stack

Recently, a LWM2M Proxy entity was introduced between the server and the client [5]. However, the proxy is not part of the LWM2M standard. The proxy acts as a group manager, managing membership of clients in the LWM2M groups. The proxy forwards messages directed to a group to all members of that group. It is also responsible for queuing, prioritizing and aggregating messages to single nodes. A LWM2M Proxy can be seen as a union of a client and a server in the same entity, with the difference that the server part of the proxy is able to access and modify the value of the object and resources defined in the client part, shown in Fig. 1. This allows implementing the interface of the group communication service as one or more LWM2M Object of the proxy. The figure shows also the LWM2M entities over Constrained Application Protocol (CoAP) [6]. CoAP is similar to Hypertext Transfer Protocol (HTTP) but adapted to low power and lossy networks. A LWM2M group is defined as a set of LWM2M nodes, where each node in the group is able to receive LWM2M requests. Thus, both LWM2M clients and proxies can be members of a group. A node has to register through a group manager (proxy) to receive requests. Each group is identified by an identifier which will be unique for the M2M domain managed by the LWM2M Server. [7]

The rest of the paper is organized as follows: Section II describes the Related Work. Section III introduces metrics and a novel evaluation method for IoT. Section IV shows the required future work based on the results of this paper. Finally, section V concludes the paper.

II. Related Work

The company SamKnows is currently working in the development of a measurement platform for IoT [8].

M-Plane is a network measurement framework [9] focusing on the Future Internet. The architecture of m-plane covers: A component (probe) which takes measurements; a client which send specifications to components to perform measurements, a supervisor which collects information from components and provide it to the clients and a repository which is a component that provides access to stored measurements. This framework has an abstract data model with JSON representation and the default session protocol is HTTP over TLS. To be adapted to IoT environments, it should be modified to handle CoAP protocol.

Bagnulo et al. [10] proposed a platform to measure traditional environments. This platform contains entities such as Measurement Agent, Measurement Controller, and Data Collector. Measurement Agents are the entities responsible for executing the measurement tasks (active, passive or hybrid measurements). Measurement Controller is the entity which distributes the measurement tasks between Measurement Agents, the corresponding time schedules, and they instruct also where and when to send the results of the measurements. The Data Collector accepts the results from Measurement Client. Measurement Peer communicate with the MA and not with the controller and collector as we show in Fig. 2. Additionally the figure shows entities which are not in scope of the current proposed lmap work, these are: Bootstrapper provides information to MAs about Controller and authentication; Subscriber parameter database contains information of the measurement context such as the medium type where the measurements take place, type of MA and time zone; Data analysis processes the measurement results and Result repository saves the measurement data. Due to how the entities and functionalities are divided, we select this model to be integrated into LWM2M architecture. This is explained in the following section.

III. Measurements and novel evaluation method for IoT

In this section, we propose a novel evaluation method to perform measurements in a constrained network environment, including description of IoT related metrics and test scenarios.

A. Metrics for IoT

Many of the metrics designed for Internet traffic measurement can be applied to IoT networks. The following metrics are described considering, first, the type of the packet (Type-P) such as TCP or UDP and second the Src (Source) to LWM2M Proxy or Server and Dst (Destination) to LWM2M Client. The metric covers related to connectivity [11], packet loss [12] and delay. It is showed in Table 1.

Other aspects: Periodic Streams [15] comprises send packets with the same size at specific times simulating a constant bit rate, e.g. analyse whether this metric is applicable to LWM2M Observe function and Bulk Transfer Capacity [16] comprises the transmission of significant amount of data a e.g. transmitting in the maximum channel capacity of the constrained network.

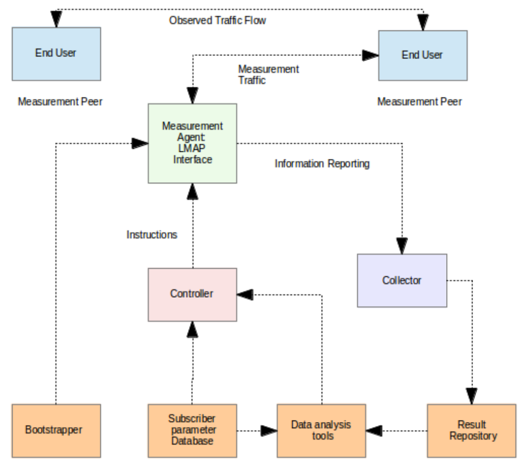

Figure 2. LMAP Measurement framework proposed

B. Scenarios for Measurement

In our work we concentrate on how to measure traffic generated from the device Management using LWM2M. We use the following objects to evaluate IoT performance measurements:

- LWM2M Group Object (ID= 26890): This object allows creation and management of group of clients, including forwarding functionality.
- RegistrationPolicy Object (ID= 21995): This object allows management of group of clients following a policy e.g. nodes that have an specific temperature value.
- GroupObserve Object (ID= 41188): This object allows creating a Group of Client and Observe resources (get an update when a resource changes) on the clients belonging to the group. Every Object Instance corresponds to one group.

Before we can create measurement methods, we have to define the scenarios from where the methods can be developed. In the following, we present the scenarios that we will study more closely.

A basic scenario comprises LWM2M Server and LWM2M Proxy in one device and in another device the LWM2M Clients. The interactions are depicted in Fig. 3 and are as follows.

1) Between LWM2M Server and LWM2M Proxy
2) Between LWM2M Proxy and LWM2M Clients
3) Between LWM2M Server and LWM2M Clients

Another scenario comprises applying LWM2M to a Capillary Networks scenario. We typically have a LWM2M Server in the cloud or operator domain, a LWM2M Proxy in the capillary gateway, and several instances of LWM2M Clients that are the managed devices. The measurement to be evaluated between LWM2M entities in Capillary Network is depicted in Fig. 4.

Additionally, we could apply this schema to a distributed proxy scenario, where the LWM2M Server and a LWM2M

Table I. METRICS FOR IOT

Metrics	Type-P	Description
Connectivity	Type-P-Instantaneous-Unidirectional-Connectivity	Evaluate whether a packet arrive from Src to Dst at an specific time.
	Type-P-Interval-Unidirectional-Connectivity	Evaluate whether a packet arrive from Src to Dst at an specific time within a range of time
	Type-P1-P2-Interval-Temporal-Connectivity	Evaluate whether there are connectivity from Src to Dst in an specific time and from Dst to Src in another specific time.
Packet Loss	Type-P-One-way-Packet-Loss	Evaluate whether Dst did not get the first bit sent by Src at an specific time.
	Type-P-One-way-Packet-Loss-Poisson-Stream	Collect sequence of pairs with Type-P-One-way-Packet-Loss at times specified in an interval of time.
Delay	Type-P-One-way-Delay [13]	Evaluate whether the Dst get the last bit of a packet with delay (defined by a time within an interval)
	Type-P-Round-trip-Delay [14]	when a packet goes from Src to Dst and Type-P-One-way-Delay from Dst to Src.

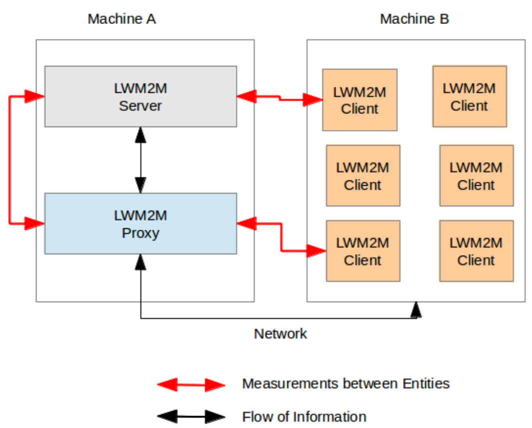

Figure 3. Basic LWM2M Scenario

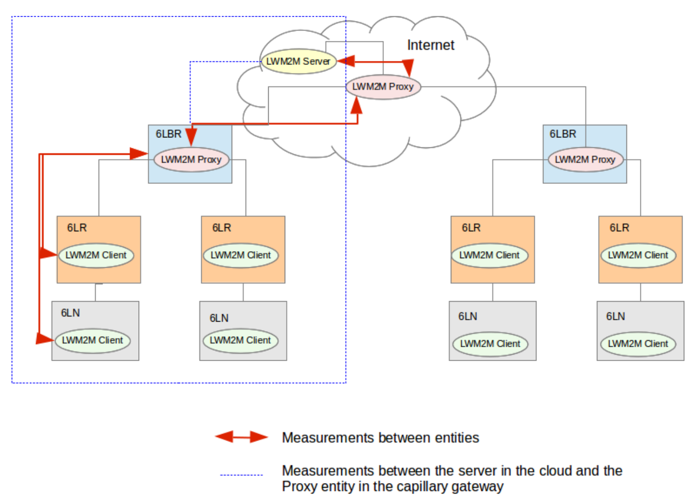

Figure 4. LWM2M Distributed Proxy Scenario in Capillary Networks

Proxy are located in the cloud. This proxy sends requests to other LWM2M Proxies in different networks. One of the advantages of this structure comprises that the proxy located in the cloud can manage the proxies located in the gateways, how it can be done is a topic for further research. The interactions are presented in Fig. 4 and are as follows:

1) Between LWM2M Proxy (cloud) and LWM2M Proxy (Capillary Network)
2) Between LWM2M Proxy and LWM2M Clients
3) Between LWM2M Server and LWM2M Proxy (cloud)

C. *Novel Evaluation Method*

We propose a model where the LMAP standard measurement platform mentioned previously could be included in LWM2M environment. This comprises a Measurement Client in a LWM2M Client, a Measurement Peer in a LWM2M Server and a Collector and Controller in a LWM2M Proxy as shown in Fig. 5

Related to Data Model, we will define or adapt the appropriate objects. In our case, they are referred to Network Performance Monitoring objects. We can use as an example the LWM2M Connectivity Monitoring object, which enables monitoring of parameters related to network connectivity. In this research instead of using OMA LWM2M Objects we

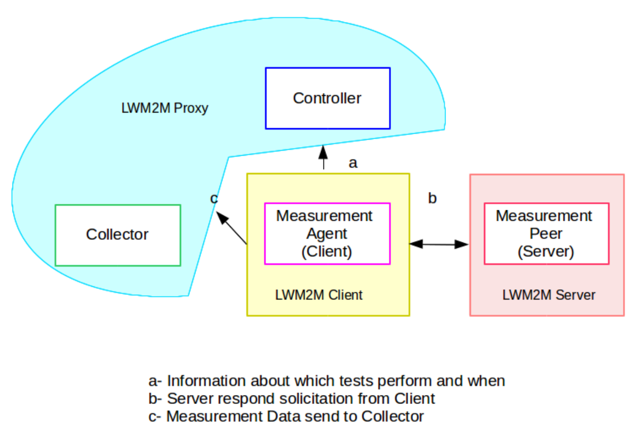

Figure 5. Functional schema of standardized measurement platform into LWM2M environment

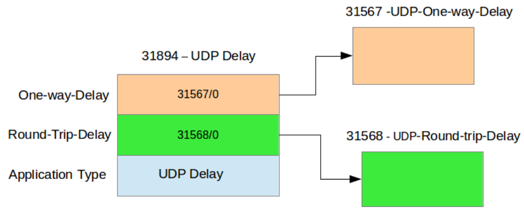

Figure 6. Example of a Composite Object: UDP-Delay

will use IPSO Objects since they enable reuse of resources. An example of a composite object is showed in Fig. 6. This example comprises a Delay metric object composed of (linked to) an UDP-One-way Delay Object and UDP-Round-Trip-Delay Object. Additionally, In our research Sensor Markup Language (SenML) is going to be used to represent performance measurements [17]. This structure collects sensor data and simple metadata of measurements and devices. The serialization for these objects is defined for different formats such as JavaScript Object Notation (JSON) e.g: a measurement from a temperature estimation encoded in the JSON syntax would be: {*"e":[{ "n": "urn:dev:oc:0988776", "v":4.5, "u":"Cel" }]*}, this array represents a single measurement for a sensor named "urn:dev:oc:0988776" with a temperature of 4.5 degrees Celsius.

IV. Future Work

We will base our future work on the measurement environment presented in this paper. Our measurements of LWM2M scenarios will focus on the performance of Proxy interactions, Gateway selections and Group Management in Capillary Networks, involving the development of a measurement platform structure oriented to IoT.

We will design and implement a testbed to measure the previous scenarios. We take into consideration how an increasing number of clients would affect memory footprint, data throughput, and message size of the LWM2M server. In particular, we evaluate the reduction of management traffic resulting from the introduction of an LWM2M Proxy in the system. Additionally, we evaluate the Distributed LWM2M Proxy environment.

V. Conclusion

IoT as an emerging networking concept inspires people to introduce new scenarios and use cases. However, the network performance measurements in the IoT are still in a primitive stage. Our work concentrates on filling this gap with a proposed new measurement concept for it.

We take current standardization efforts as the starting point and used them as the basis for our future work for IoT networks. This topic will be the key for developing the future Internet services and networks to support IoT.

Acknowledgment

This work is funded by the FP7 Marie Curie Initial Training Network (ITN) METRICS project (grant agreement No. 607728)

Additionally the authors would like to thank Jörg Ott, Nicklas Beijar and Jaime Jimenez for their constant support and advices in our researh.

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