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SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Audiovisual services

Capabilities of ubiquitous sensor networks for supporting the requirements of smart metering services

Recommendation ITU-T F.747.1

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Recommendation ITU-T F.747.1

Capabilities of ubiquitous sensor networks for supporting the requirements of smart metering services

Summary

Recommendation ITU-T F.747.1 identifies the capabilities of ubiquitous sensor networks (USNs) for supporting the requirements of smart metering services. To this end, an overview of smart metering is described, with a clarification between smart grids and smart metering provided. This Recommendation takes into account a few typical use case scenarios of smart metering and identifies the general requirements and USN-based smart metering services to support these use cases. Finally this Recommendation defines USN capabilities based on identified requirements for providing smart metering services.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T F.747.1	2012-06-29	16

Keywords

Smart grid, smart metering, USN.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Recommendation ITU-T F.747.1

Capabilities of ubiquitous sensor networks for supporting the requirements of smart metering services

1 Scope

The main purpose of this Recommendation is to identify the capabilities of ubiquitous sensor networks (USNs) which support the requirements of smart metering services. The scope of this Recommendation covers the following:

– overview of smart metering

– smart metering use case scenarios

– requirements of smart metering services

– USN capabilities for supporting the requirements of smart metering services.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T F.744] Recommendation ITU-T F.744 (2009), *Service description and requirements for ubiquitous sensor network middleware*.

[ITU-T Y.2221] Recommendation ITU-T Y.2221 (2010), *Requirements for support of ubiquitous sensor network (USN) applications and services in the NGN environment*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 sensor [ITU-T Y.2221]: An electronic device that senses a physical condition or chemical compound and delivers an electronic signal proportional to the observed characteristic.

3.1.2 sensor network [ITU-T Y.2221]: A network comprised of inter-connected sensor nodes exchanging sensed data by wired or wireless communication.

3.1.3 sensor node [ITU-T Y.2221]: A device consisting of sensor(s) and optional actuator(s) with the capabilities of sensed data processing and networking.

3.1.4 ubiquitous sensor network (USN) [ITU-T Y.2221]: A conceptual network built over existing physical networks which makes use of sensed data and provides knowledge services to anyone, anywhere and at any time, and where the information is generated by using context awareness.

3.1.5 USN gateway [ITU-T Y.2221]: A node which interconnects sensor networks with other networks.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 demand response: A smart metering feature that allows consumers to reduce or change their use patterns of electricity, gas and water during peak demand usually in exchange for a financial incentive.

3.2.2 sensor network gateway: A sensor network element that connects a sensor network to another network with different architecture or protocols, permitting information exchange between them. See also USN gateway.

NOTE – Sensor network gateway functionalities may include either address or protocol translation or both.

3.2.3 smart grid: An electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies.

3.2.4 smart meter: A device in a user's premises for monitoring and controlling electrical power, gas and water usage of home appliances based on demand response information from home appliances.

3.2.5 smart metering: An operation to provide information to consumers and smart metering operators about energy consumption. The information includes how much energy the consumers are using or generating and how much it costs.

3.2.6 smart metering gateway: See USN gateway.

3.2.7 utility: An entity providing services such electricity, gas, water and heating to the general public and/or to industrial and commercial entities.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

USN Ubiquitous Sensor Network

5 Conventions

None.

6 Overview of smart metering

Smart meters are utility meters, for example electricity, gas, water and other meters, which may bring about the end of estimated bills and meter readings, and provide customers and energy distributors and suppliers with accurate information on the amount of a utility that is being used.

Smart metering provides:

– customers with the information they require to become energy savvy and make smarter decisions about their energy usage;

– energy suppliers with the means to better understand and service their customers;

– distributors with an effective tool to better monitor and manage their networks.

In addition, smart metering enables those customers who choose to generate their own electricity (micro-generators) to be financially rewarded for their contribution to the national grid, and for distributors to better manage this contribution [b-ETSI TR 102 691].

Smart metering may be regarded as one of the key technologies for smart grid systems.

6.1 Smart grids and smart metering

A smart grid is a type of electrical grid that attempts to predict and intelligently respond to the behaviour and actions of all electric power users connected to it – suppliers, consumers and those that do both – in order to efficiently deliver reliable, economic and sustainable electricity services including:

– enhancement of reliability
– reducing peak demand
– shifting usage to off-peak hours
– lower total energy consumption
– actively managing electricity charging
– actively managing other usage to respond to other renewable resources.

Smart grid technologies have already been used in other applications, such as manufacturing and telecommunications. In general, smart grid technology may be divided into seven areas: integrated communications, sensing and measurement, smart metering, advanced components, advanced control, improved interfaces and decision support, and smart power generation. In other words, smart meters are key components of smart grids and consequently, smart metering is one of the crucial features for smart grids.

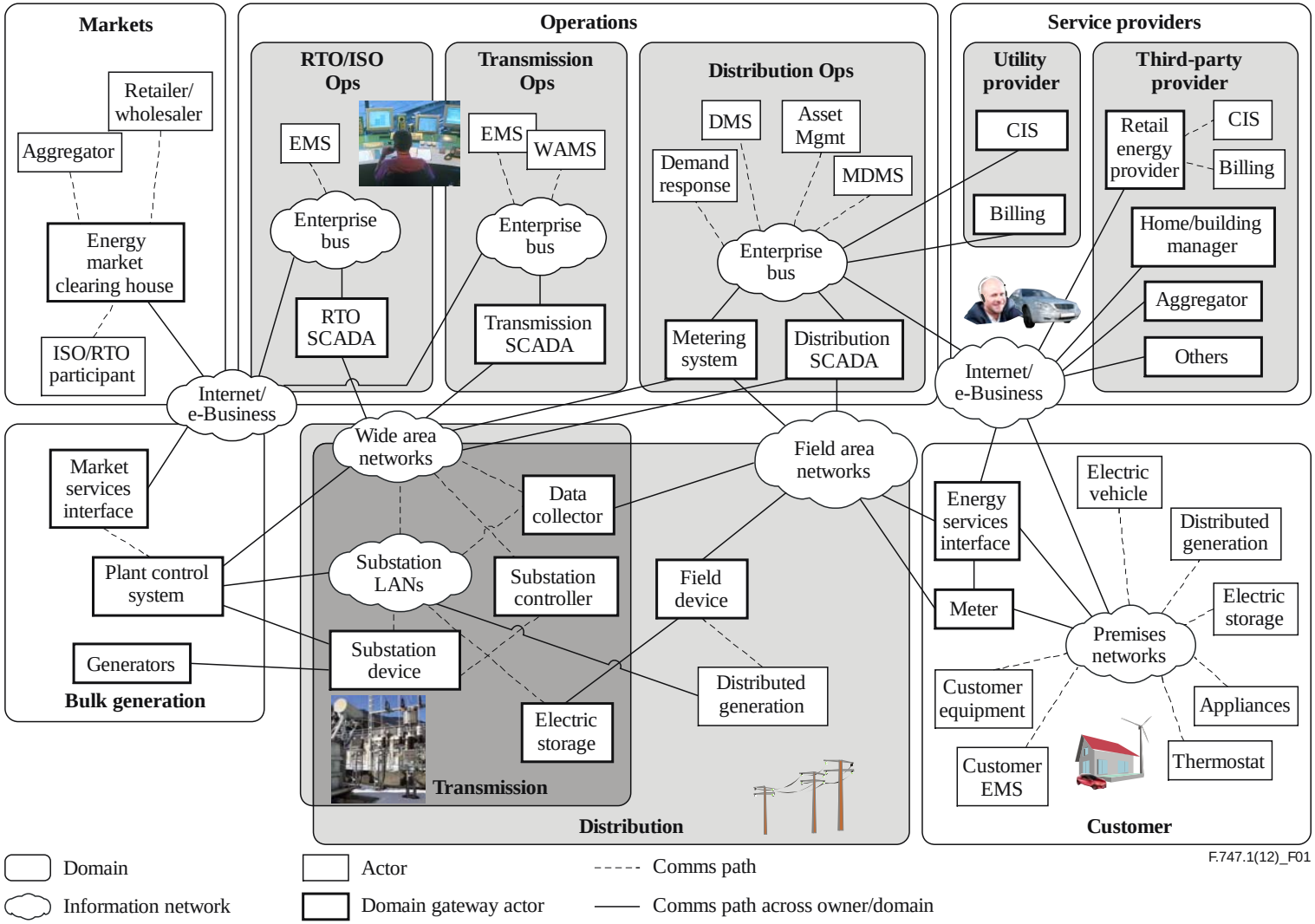


Figure 1 – Smart grid architecture [b-NIST]

6.2 Technical overview of smart metering

It is not only governments and utility companies, such as electricity, gas and water suppliers, but also researchers, that have been interested in automatic meter reading based on communication systems. Examples of smart metering benefits to customers, governments and utility companies are:

– lower metering cost
– energy savings for residential consumers
– reliability of supply
– various pricing schemes to attract new costumers
– easier detection of fraud and of outages
– automated billing.

Smart metering comprises metering and exchange of meter information between smart meters and utility companies. Various technologies can be used for metering and exchanging meter information. For example, power-line communications have been used for delivering electricity power to consumers and for transmitting gas and water measurements to utility providers. Alternatively, mobile networks can be used for exchanging messages in an automatic meter reading system.

Sensor network technologies may be used for metering and collecting information of utility usage, and communication networks can be used for exchanging the information. Figure 2 depicts an overall diagram of smart metering systems. The meter information, obtained from home appliances by sensor nodes is collected and delivered to operators of utility companies.

The operators manage the collected information and inform consumers of variable pricing information or enforced load control messages. Such operators' actions may lead to consumers' reducing energy consumption.

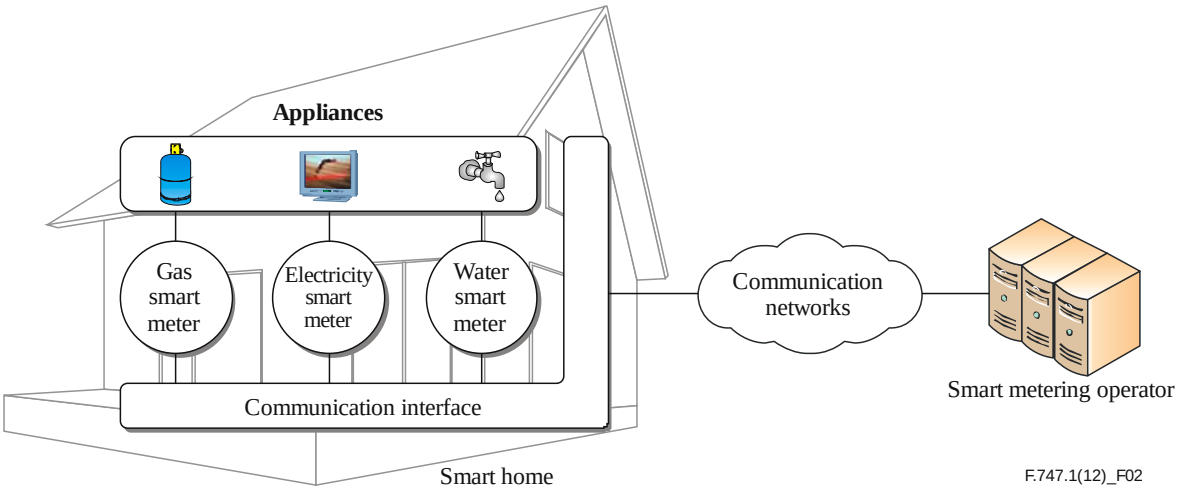


Figure 2 – Overview of smart metering

6.3 USN-based smart metering services

The smart metering services shown in Figure 3 require technological facilities to support metering, and to exchange metering information between smart meters and metering operators in utility control centres.

The basic characteristic of USN applications and services are gathering data by sensor networks and data transmission to a remote server through communication networks. Also, control information is transmitted to sensor networks from the remote server. Furthermore, if USN middleware is deployed, the middleware can provide USN applications or sensor networks with various functions such as data query, data mining, event processing, sensor network metadata directory service, data filtering, context-aware rule processing and sensor network management.

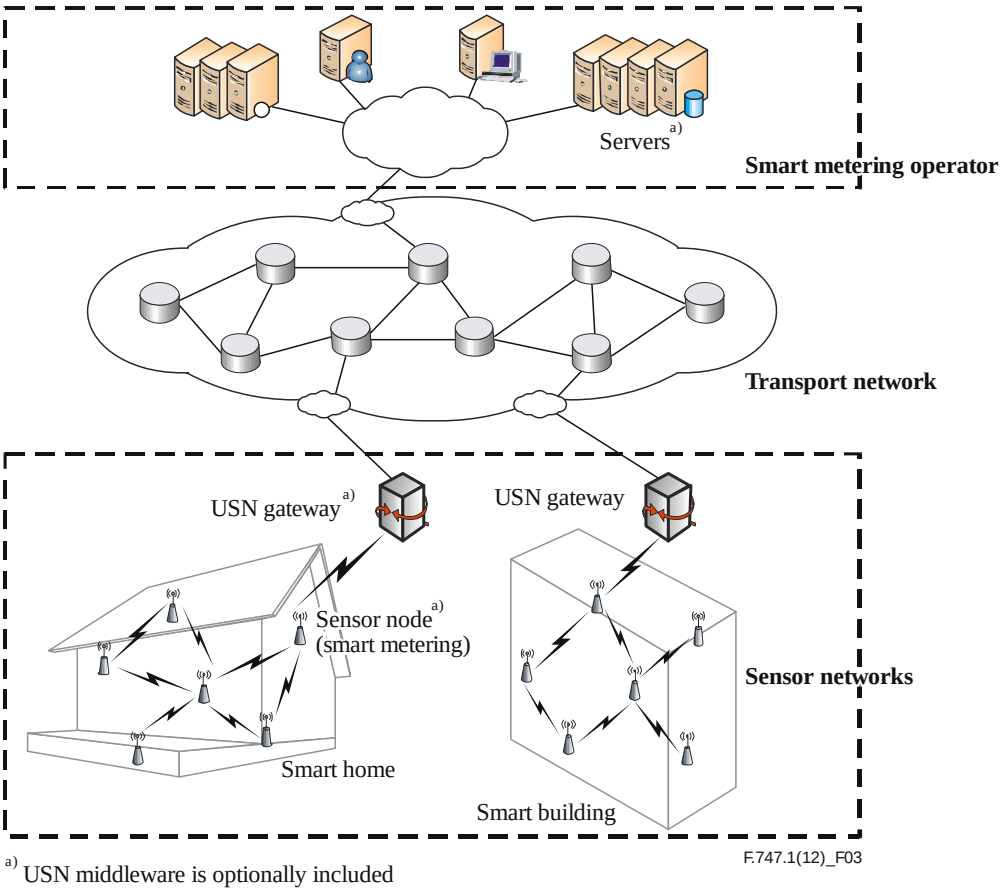
These USN features can be applied to smart metering services. Sensor nodes in sensor networks have the capabilities of metering and delivering metered information to a server at a utility control centre. USN middleware can provide functions which are required by an on-demand remote meter reading scenario and a demand response meter reading scenario.

A smart metering system can be implemented by sensor nodes and USN middleware as follows:

– Smart metering sensor nodes: Each sensor node may have smart metering capabilities, therefore, sensor nodes can act as smart meters supporting the processing of smart metering information for smart metering procedures, such as meter reading collection and tariff setting.

– Smart metering gateway: A sensor network gateway or a USN gateway is capable of connecting a sensor network to another network with different architecture or protocols, permitting information exchange between them. Therefore a sensor network gateway or a USN gateway can be used as a smart metering gateway. A smart metering gateway is only responsible for delivering information between the sensor nodes (smart meters) and metering operators. In cases where a gateway has smart metering capabilities, it collects meter reading data and then delivers it to the metering operator(s).

– USN middleware [ITU-T F.744]: USN middleware provides data filtering, data query, data mining and context-aware rule processing, etc. These features of USN middleware satisfy meter reading data processing requirements and can be applied to an on-demand remote meter reading scenario and a demand response meter reading scenario.



a) USN middleware is optionally included

Figure 3 – Smart metering services based on USN

7 Smart metering service scenarios

The following scenarios illustrate the use of smart metering services.

7.1 Scenario I: Regularly scheduled remote meter reading

Scenario I in Figure 4 describes procedures where meter reading data are delivered to smart metering operators at regularly scheduled intervals.

1) A smart metering operator sends a message including schedule information to smart meters.
2) Smart meters are configured with the schedule for measurement and data transfer.
3) According to the schedule, smart meters measure energy consumption from home appliances and obtain measurement data.
4) The smart meters deliver the data to the smart metering operator.

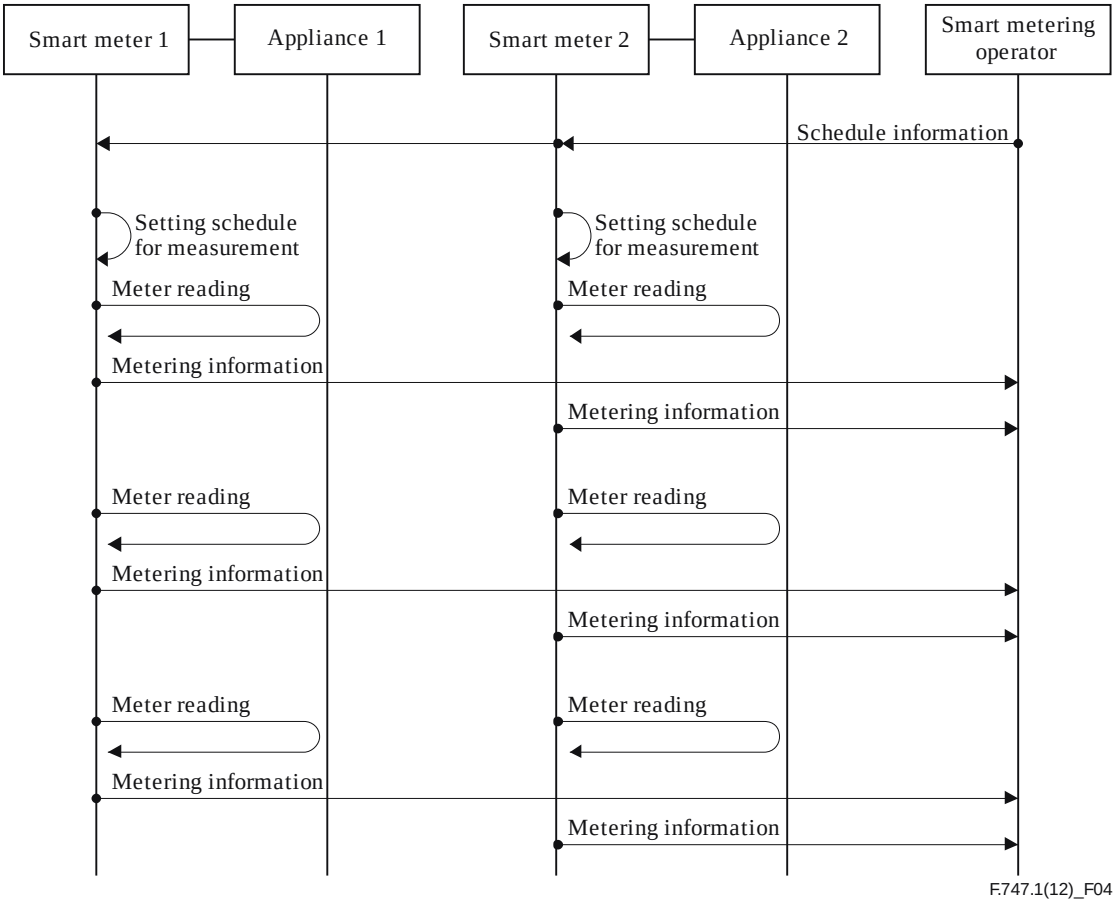


Figure 4 – Scenario I: Regularly scheduled remote metering

7.2 Scenario II: On-demand remote meter reading

Scenario II in Figure 5 describes the procedures for when smart meters measure energy consumption and deliver the results to a smart metering operator on demand.

1) When a smart metering operator collects measurement data from the smart meters, the operator sends a task message for smart meters to collect measurement data.

2) Smart meters verify the operator's message and, if the message is validated, they measure energy consumption.

3) The resulting data are delivered to the smart metering operator.

NOTE – Figure 5 does not include the flow for the message verification, as this can be performed in a number of ways.

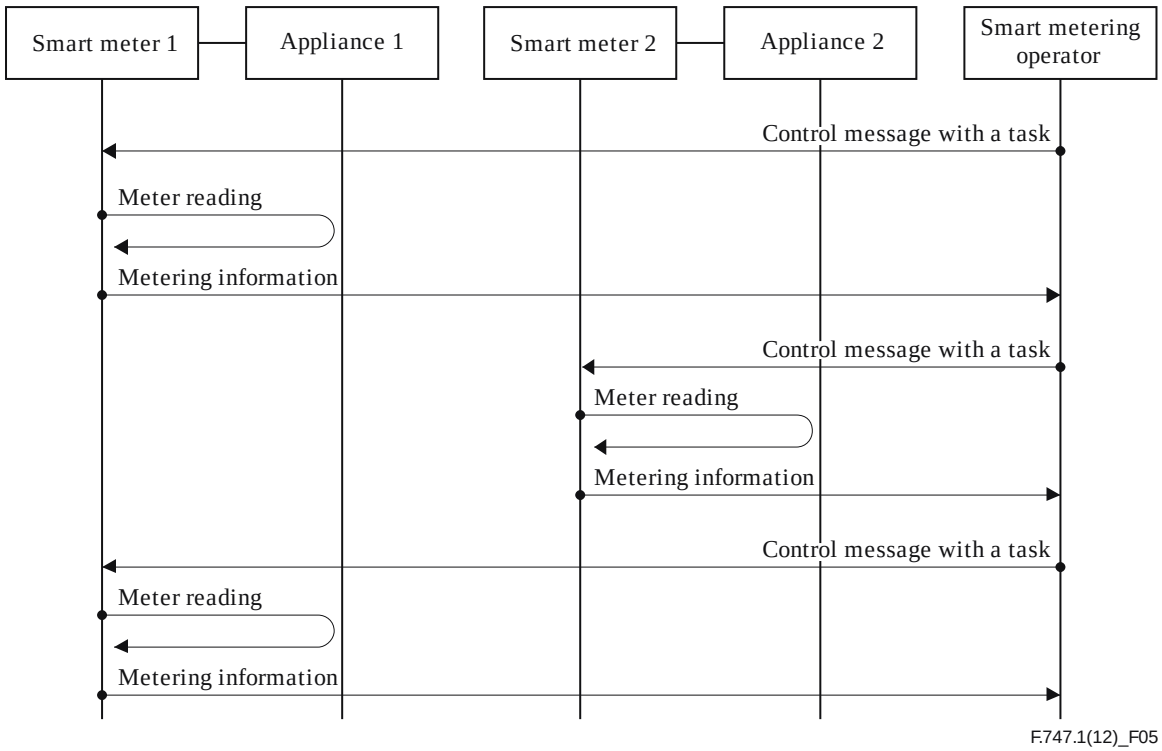


Figure 5 – Scenario II: On-demand remote meter reading (excluding the verification step)

7.3 Scenario III: Demand response

Scenario III illustrated in Figure 6 describes customers responding to the metering operator's demands.

1) A smart metering operator sends a message including schedule information to smart meters.
2) Smart meters are configured with the schedule for measurement and data transfer.
3) When the number of home appliances turned on simultaneously is on the increase, the total amount of energy consumption also steeply increases.
4) Information about the increasing amount of energy consumption is being reported to the smart metering operator at scheduled intervals, and the price of energy may also change according to the tariff policies (e.g., depending on supply and demand).
5) (a) The smart metering operator sends a message to inform consumers of the price change.

   (b) The smart metering operator sends load control messages to enforce the reduction of energy consumption or to force shut off due to a management policy.
6) (a) Smart meters display the message to the consumers, and the consumers may decide to reduce energy consumption, or the home appliances may be switched off by the consumer.

   (b) When receiving the load control messages, the smart meter displays the message and proceeds to shutting off the connected home appliance.

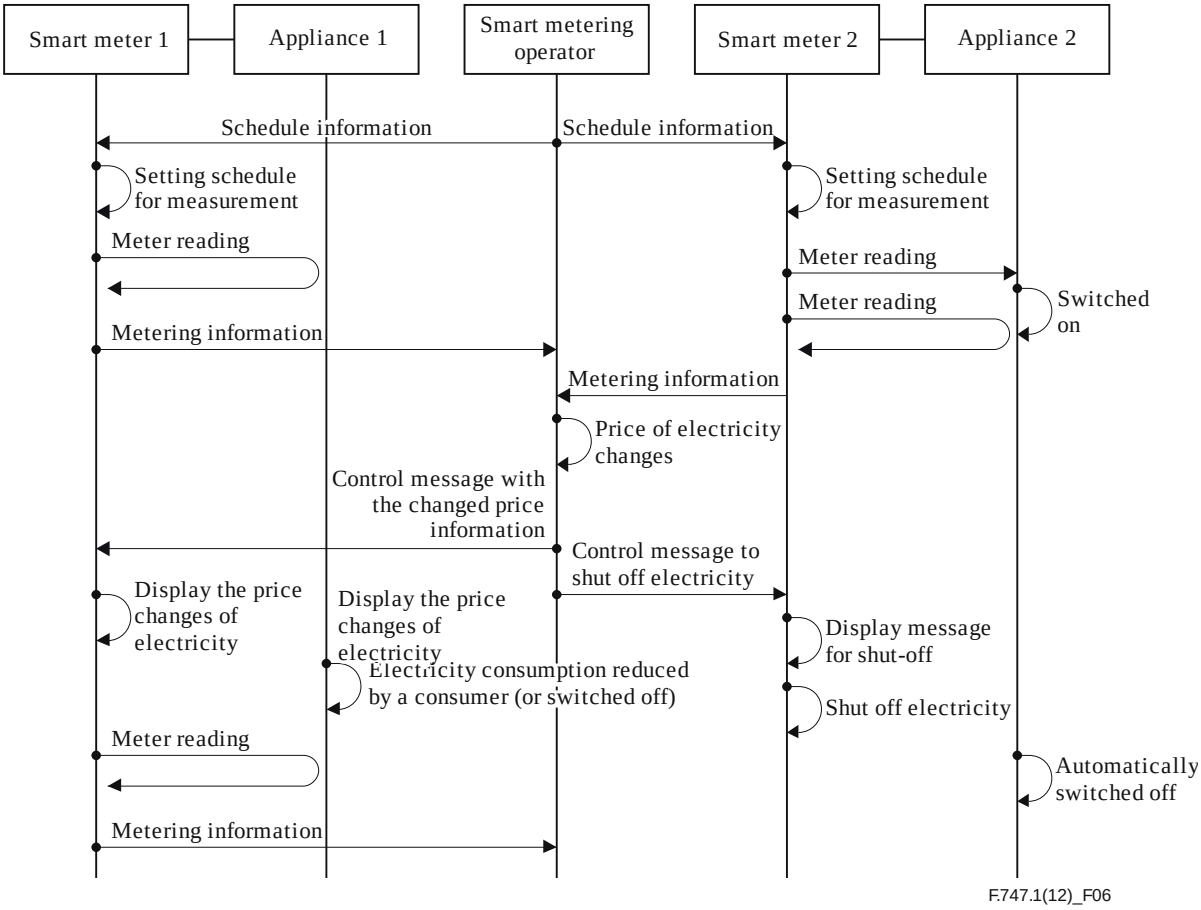


Figure 6 – Scenario III: Demand response

7.4 Scenario IV: Tariff configuration

Scenario IV, illustrated in Figure 7 describes how the price of energy consumption is decided and configured within the meters.

1) A smart metering operator sends a message including schedule information to smart meters.
2) Smart meters are set up with the schedule for measurement and data transfer.
3) The smart meters regularly deliver meter reading data to the metering operator according to regularly scheduled intervals.
4) The price of electricity may be dynamically changed by pricing policies (e.g., depending on supply and demand).
5) When the price changes, a message including changed price information is delivered to all the smart meters concerned.
6) The changed cost information may be shown on their displays, and the new cost is applied.

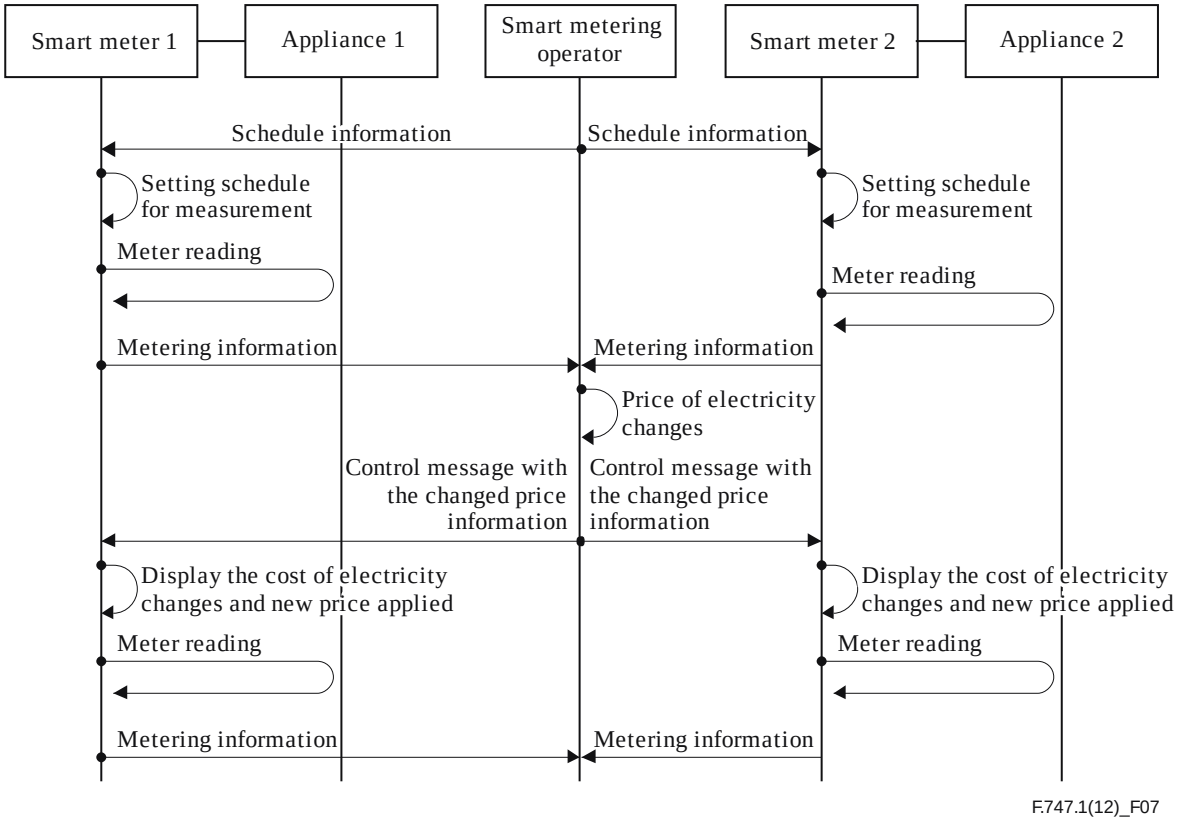


Figure 7 – Scenario IV: Tariff configuration

7.5 Scenario V: Meter reading data aggregation

This scenario describes the procedures of how meter reading data, obtained at scheduled intervals by smart meters, are collected at an aggregating smart meter (or at an aggregating smart metering gateway) and then delivered to metering operators.

1) A smart metering operator sends the smart meters a message to request aggregated metering data.
2) Smart meters are configured to obtain meter reading data.
3) According to the schedule, smart meters measure energy consumption and obtain meter reading data from home appliances.
4) The obtained meter reading data are collected in an aggregating smart meter (or aggregating smart metering gateway). This is represented by Smart meter 2 in Figure 8.
5) Finally, meter reading data are transferred to a smart metering operator.

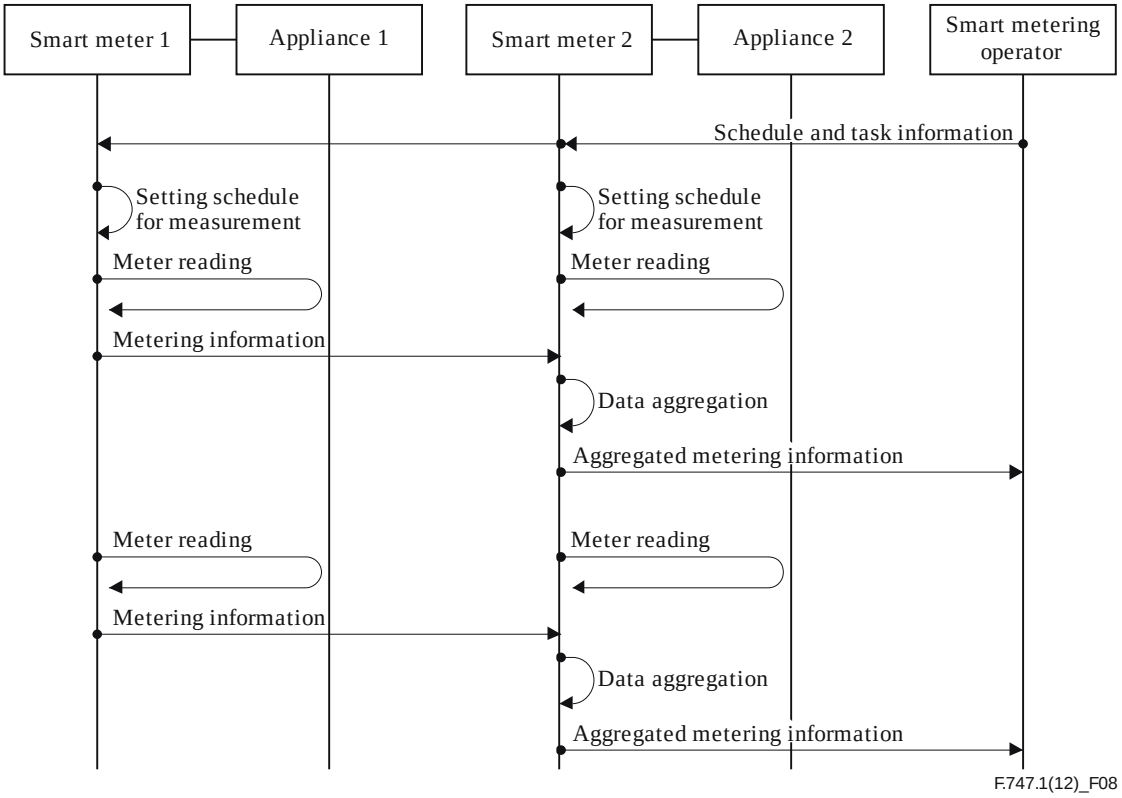


Figure 8 – Scenario V: Meter reading aggregation

8 Network and USN requirements for smart metering services

This clause specifies the sub-set of smart metering service requirements that relate to sensor networks and USNs.

8.1 Time synchronization

In smart metering services, exchanged data uses time stamps between smart meters and the systems of smart metering operators. Therefore, accurate and secure time synchronization should be supported in smart metering systems.

8.2 Reliable information delivery

In smart metering services, meter reading data can be frequently transferred from distributed meters, and also operators can send many control messages to smart meters. If delivery has failed, the operators cannot collect all of the meter reading data from smart meters. Therefore, smart metering services are required to provide reliable information delivery, such as meter reading data and control messages described in the scenarios of clause 7.

8.3 Minimal time delay

In the case of on-demand remote meter reading, a meter reading request and response should be delivered to the requesting entity with a minimal time delay.

8.4 Real-time delivery of meter reading data

The demands of smart metering operators require real-time responses of interconnected consumer premises equipment. Additionally, meter reading data are required to arrive at the metering operators in real-time (e.g., step 3 of scenarios I and II). Smart metering services are required to guarantee real-time data exchange.

8.5 Bidirectional communication between meters and operators

Meter reading data are delivered from smart meters to smart metering operators as shown in step 3 of scenarios I and II, and step 2 of Scenario III. Control messages are also sent to and from the operators and the smart meters (e.g., in step 5 of Scenario III and step 3 of Scenario IV). In order to achieve this, smart metering services are required to support bidirectional communication between meters and operators.

8.6 Security support including the authorization of operator and data confidentiality

Operators need to control meters so that the meters take action in accordance with their instructions. In this case, the operators should be authorized by smart meters to take actions to secure against unauthorized access (step 2 of Scenario II).

As metering information may include personal information, it should not be revealed to unauthenticated third parties. Therefore, it is required to secure metering information from access by unauthenticated third parties as well as to support the integrity check of the data exchanged.

8.7 Authentication of smart meters

Smart meters should be authenticated by smart metering applications. Authentication of smart metering devices can be achieved directly by smart metering applications, or by the authenticated smart metering gateways.

8.8 Meter reading data processing

Both operators and smart meters should be able to perform data processing on meter reading, such as filtering, validation and aggregation. In some cases, data mining processing is necessary, for example, analysing patterns and predicting some events.

8.9 Monitoring and management of smart meters

Smart meters or smart metering gateways should be monitored proactively in order to attempt to prevent and to correct errors. In addition, the following management capabilities should be supported from the network side:

– secure software and firmware provisioning

– configuration management

– auto-configuration functions for smart meter area networks

During the operation of smart metering services, smart metering applications should be able to specify a regular reporting schedule (Scenario I) for specific parameters and specific metering devices. Also, smart metering applications should be able to modify the value of the requested time period. Smart metering applications should be able to change the tariff configuration of smart meters when needed.

9 USN capabilities for smart metering services

9.1 Time synchronization

USN is required to support accurate and secure time synchronization among sensor nodes, sensor network gateways and smart metering applications.

9.2 Reliable transmission

Smart metering requires reliability of metering information delivery to ensure correct results. Therefore, a USN is recommended to guarantee the reliable transmission of measurement data and message delivery.

9.3 Scalability

New smart meters (sensor nodes) can be added to, or one of the existing meters (sensor nodes) can be removed from an existing smart metering group (sensor networks). Such a change should not degrade the performance of the smart metering service. Therefore, sensor networks in USNs are required to support scalability.

9.4 Mobility support

In some cases, a consumer can change the location of home appliances. This change may require changes in a meters' position in the intra-sensor network or inter-sensor networks. Therefore, sensor networks in USNs are recommended to support the mobility of smart meters (sensor nodes).

9.5 Delivery latency

Meter reading data should be delivered with a minimal time delay or within a pre-set time. Therefore, a USN is recommended to guarantee data delivery with a minimal time delay or within a pre-set time.

9.6 Fault detection and recovery

Link failure between wireless nodes is possible due to the characteristics of wireless transmission. Such failure can present negative effects on the reliability and delivery latency of smart metering services. A USN is recommended to detect link failures and recover from such failures.

9.7 Security supporting confidentiality, integrity check, authorization and authentication

Meter reading data and messages may be transferred to/from operators and meters by hop-by-hop transmission amongst sensor nodes. Therefore, hop-by-hop security among sensor nodes is recommended to be implemented and a USN is recommended to provide an integrity check of the data exchanged. In addition, the USN is recommended to provide smart meters with authorization capabilities for access to smart meters of smart metering operators.

Smart meters should be authenticated by smart metering applications directly, or through a smart metering gateway. Therefore, a USN is recommended to provide an authentication capability to smart metering applications for the authentication of smart meters (sensor nodes).

9.8 Connectivity

Meter reading data, obtained from each sensor node, are collected by a gateway, and then the collected meter reading data are delivered to smart metering operators through transport networks. In addition, control messages of the operators are also delivered to each sensor node. In order to achieve this, it is recommended that connectivity be guaranteed amongst sensor nodes, between sensor nodes and the gateway, and between the gateway and outer networks.

9.9 Unicasting and multicasting

A unicast networking service is required to be supported amongst sensor nodes so that meter reading data are delivered to smart metering operators. Furthermore, control messages of the metering operators should be delivered to all sensor nodes. Therefore, multicast networking support is also required.

9.10 Data aggregation

Meter reading data from smart meters is collected and aggregated at a smart meter (sensor node) or at smart metering gateways, prior to data transfer to smart metering operators. Therefore, USN sensor nodes and gateways are required to support data aggregation.

9.11 Distributed processing

If there are a number of smart meters (sensor nodes) in a smart home or building, a large number of meter reading data sets may be sent at the same time to a smart metering operator. To prevent node and service failure because of burst data centralization, distributed processing is required.

9.12 Monitoring and management of sensor nodes

Smart meters (sensor nodes) or smart metering gateways (sensor network gateways) are recommended to be monitored and managed proactively in order to attempt to prevent and correct errors including secure software and firmware provisioning and configuration management, as well as, auto-configuration functions for sensor networks.

Smart metering applications may also require a change of parameters in the smart meter for regularly scheduled reporting, as well as for changing tariff configuration. For satisfying this requirement, a USN is recommended to support the remote configuration setting and re-setting of sensor nodes acting as smart meters.

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