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ITU-T L.1500 – Standardization gap analysis for smart water management

ITU-T L-series Recommendations – Supplement 14

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Supplement 14 to ITU-T L-series Recommendations

ITU-T L.1500 – Standardization gap analysis for smart water management

Summary

Supplement 14 to the ITU-T L-series Recommendations identifies gaps on standardization for smart water management (SWM), taking into consideration related information and communication technology (ICT) standardization activities currently undertaken by the various standards development organizations (SDOs) and forums.

The final objective of this Supplement is to suggest potential strategic SWM related standardization activities based on the investigation of the gaps, and to encourage other ITU Study Groups and other SDOs to get involved in the work for a wider standardization roadmap.

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FOREWORD

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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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Table of Contents

Supplement 14 to ITU-T L-series Recommendations

ITU-T L.1500 – Standardization gap analysis for smart water management

1 Scope

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The final objective of this Supplement is to suggest potential strategic SWM related standardization activities based on the investigation of the gaps, and to encourage other ITU Study Groups and other SDOs to get involved in the work for a wider standardization roadmap.

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3 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AES Advanced Encryption Standard

CEN European Committee for Standardisation

CIP Critical Infrastructure Protection

CSIRO Commonwealth Scientific and Industrial Research Organisation

CUAHSI Consortium of Universities for the Advancement of Hydrologic Science Inc.

D2D Device to Device communication

ERP Enterprise Resource Planning

GCSE Group Communication System Enabler

GEO Group on Earth Observation

GEOPRIV Geographic Location/Privacy

GEOSS Global Earth Observation System of Systems

GIS Geographic Information System

GML Geography Mark-up Language

GRIDMAN Greater Reliability in Disrupted MAN

IOPS Isolated E_UTRAN Operation Public Safety

MCPTT Mission Critical Push to Talk

MMI Man Machine Interface

OGC Open Geospatial Consortium

OMA Open Mobile Alliance

OWL Web Ontology Language

POC PTT Over Cellular

PPDR Public Protection and Disaster Relief

ProSe Proximity based Service

PTT Push to Talk

RDF Resource Description Framework

SCADA Supervisory Control and Data Acquisition

SOA Service Oriented Architecture

SWE Sensor Web Enablement

SWG Smart Water Grid

SWM	Smart Water Management
TETRA	Terrestrial Trunked Radio Access
3GPP	3G Partnership Project
URI	Uniform Resource Identifiers
W3C	World Wide Web Consortium
WIRADA	Water Information Research and Development Alliance
WMO	World Meteorological Organization
XML	Extensible Mark-up Language

4 Framework of gap analysis for SWM standard technology

4.1 Procedure used in the development of this "gap analysis"

Gap analysis, in general, identifies gaps between the optimized allocation of the resources and the current allocation level. In standardization, gap analysis usually focuses on the activities currently undertaken by the various standards development groups to identify potential/required standardization activities, so as to provide suggestions for standards development group(s) [GapsforSSC].

In that sense, the first question to be asked is: "What kind of standardization activities are to be collected and reviewed for the study of gaps for SWM?". And as focus is being placed on the ICT aspect, ITU-T technology watch report "ICT as an enabler for smart water management" [TWR2010] should be taken into account. The report contains the following list of standardization domains identified in smart water management:

– weather forecasting and climate monitoring;
– emergency communications;
– consumer interface for smart grid;
– smart metering;
– GIS standards;
– semantic sensor Web;
– water ML2.0.

Although most of those categories share technology with other initiatives and are generally global issues covering wide areas of technical solutions and standards, obviously it could be the initial category from which standards are selected that would support SWM. However, there is an issue not yet very active in SWM, which is the "Consumer interface". Since the water system still has relatively low demand response and low need of home networking for prosumer's involvement in the operation, the consumer interface accordingly has no high value in water sector as yet.

Meanwhile, there are other issues not reflected in the list, such as the "interoperability model", which identifies the relationship and interworking aspect of players in the entire system or business ecosystem. Though this model is the architectural basis of developing most of the standards for the entire system, there is still not much activity dealing with this in SDOs. ITU-T report "Partnering for solutions: ICTs in Smart Water Management" [ITU-T 2014] provides related information to it, "the stakeholders involved in ICTs and SWM", which is useful to start developing the interoperability model.

Another issue which is necessary for the installation of networking infrastructure for SWM is critical infrastructure protection. Water system is basically a critical infrastructure which is fundamental for the functioning of a society and economy, so it typically requires a certain level of assured preparedness and response to serious incidents that involve the system in the region, embodied in the concept of critical infrastructure protection (CIP). A secure industrial network and control system is essential for the realization of CIP, which typically strives for the efficiency and reliability of a single, often fine-tuned system. As ICT plays a wider role in SWM by enabling a broader range of open communication services required within modern businesses, cybersecurity should also be considered in order to legitimate and control the use of information within the organization. Consideration should also be given to the regulatory standards issues involved in the audit control for the infrastructure. CIP is also related to disaster engineering [CINSEC].

Finally consideration should be given to the standards from ISO/IEC for water processing, since many of them have overlapping context of standard issues for industry and ICT.

By adding new issues and eliminating "Consumer interface" from the list, we now have the following new list of technical domains as a starting point for the investigation:

– weather forecasting and climate monitoring;
– water ML2.0;
– semantic sensor Web;
– GIS standards;
– emergency communications;
– interoperability model;
– critical infrastructure protection and disaster engineering;
– smart metering;
– water processing.

In order to investigate the gaps in SWM standardization, the activities in these domains will be summarized and allocated to the layers of a conceptual model of SWM. By doing the allocation, the domains will be grouped into the levels of interworking in the system to provide more information of potential needs of standard technology for vertical and horizontal interworking. Thereafter, a table for mapping "technical domains" to "standard organizations" will be created to set the actual standardization activities visible in each cross section. Gaps in the table are identified by blanks indicating potential future area of standardization.

4.2 Conceptual model of SWM

As focused in FG SWM TR "The Role of ICT in Water Resource Management" [RoleOf ICT], the technical evolution of ICT tools and their potential impact and benefit to water sector have been identified since the last decade. The report illustrates major ICT means as applied to water systems with convergence and integration capabilities. New capabilities and services in water management systems can be organized into different layers. Figure 1 illustrates the major building blocks of smart water management architecture identifying the major functions of each layer.

4.2.1 Meters and sensors

As the traditional water management system is perceived to be in the bottom level of the conceptual model, in this Supplement it will be referred to as "Water infra layer", which consists of two sub layers: "structural infra layer" and "non-structural infra layer". The expression "structure" has its roots in civil engineering which has led the construction of traditional water management systems. The first tool, "meters and sensors" is the major contributor in these sub layers, to bring innovations such as smart metering into the system.

4.2.2 Communication infrastructure

On the top of the "water infra layer", the second tool, "communication infrastructure", can be deployed to connect many entities in underlying water infra layer, to establish an integrated management system as a typical capability of innovation. It enables the enhancement of the efficiency and reliability of enterprise system due to the system level integrated controls. This communication capability also contributes to wider communication with other entities in the level of interworking, such as for emergency communication and new business applications. This new layer based upon the communication infrastructure's capability is thus called "integrated control and interworking layer" in this Supplement. Since this network would be a critical infrastructure in many countries, the water authority will prefer to own and protect the network as a critical infrastructure network. Some guidelines and regulations for design, implementation, and operation are required.

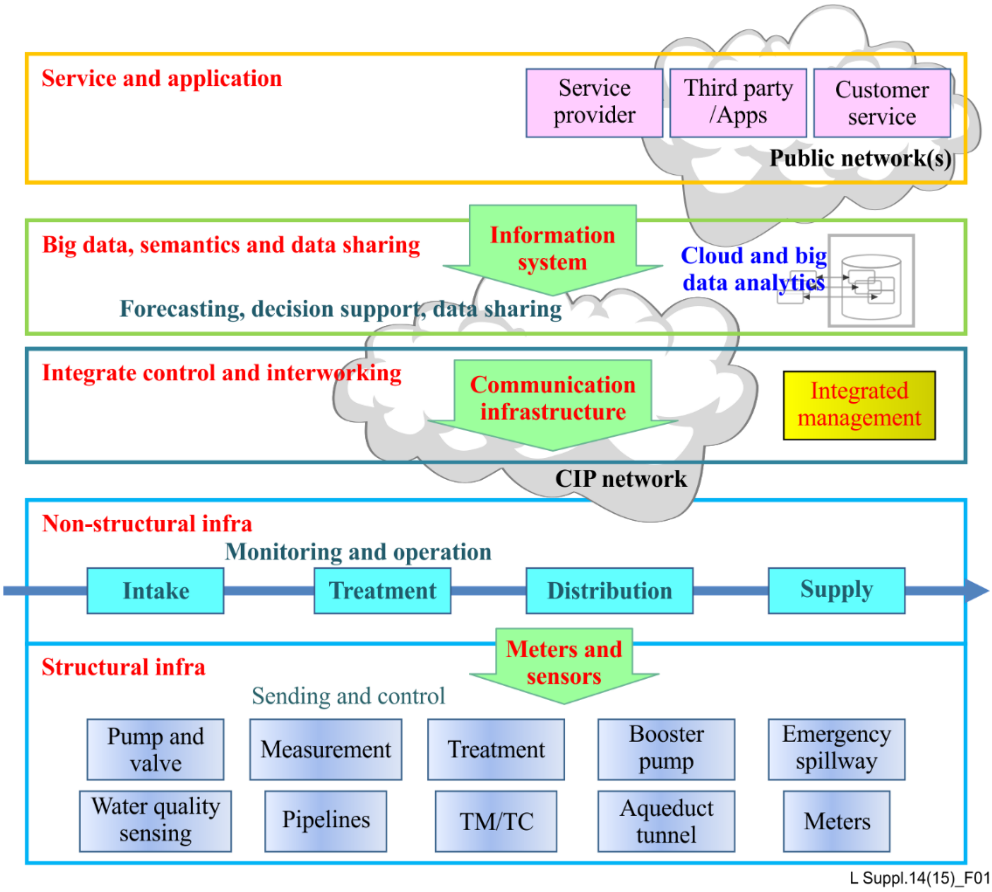

Figure 1 – Conceptual model of water management system with ICT

4.2.3 Information system

As shown in Figure 1 advanced information systems are emerging based on the 'integrated control and interworking layer", especially for the innovation functions of water management such as forecasting, analytics and decision support with information and data sharing capabilities. These information systems include integrated databases, semantics interoperability, cloud based data centres, big data functions and others featured in the "Semantics and data sharing layer" in this Supplement. This new capability of advanced information systems provides new potentials of the SWM system, by means of information exchange, integration, analysis, and prediction capabilities.

The service and application layer which, based on the semantics and data sharing layer, will provide open connectivity to external information systems to share the information and to interwork with external or public services.

4.3 Domains of standardization in the SWM model

The layers in the system identified during the examination of the major tools of innovation for SWM can be generalized, in order to make the system more inclusive, as shown in (Figure 2). The technical domains identified in clause 4.1 are allocated along with the procedure explained in the clause, to show a simple grouping within the layers in the figure. The result of the allocation gives us, first, an overall understanding on the grouping of the technical domains allocated to the layers,

The incorporation of details of the functional entities/actors and how they interact horizontally or vertically is a step by step process that will appear in the system under innovation. This results first in a detailed conceptual diagram of SWM, and second in a list of standards related to any parts of the diagram. It was also promised that if the work goes on a successful track, classification of the standards and the table of current activities will be obtained.

4.3.1 The water infra layer

Water processing standards, smart metering, and critical infrastructure protection are the major issues and activities related to this layer to enforce innovation.

4.3.2 Integrated control and interworking

Interoperability model, emergency communication, disaster engineering, and critical infrastructure protection are the major issues and activities in this layer to build an integrated system.

4.3.3 Semantic and data sharing

Geographic information system (GIS) standards, weather forecasting and climate monitoring, WaterML2.0, and semantics sensor Web are the major standardization issues and activities emphasized in this layer for sharing information and knowledge to build intelligent systems.

4.3.4 Others

Although there is another layer of service and application in SWM, it is not examined in this Supplement as not many dominant activities of standardization are recognized in that area as yet. However, it is expected that many innovative technologies will emerge in this open and public area as a response to the needs of consumers, and their convenience, together with innovation in traditional water management.

The following clauses outline the technical domains identified and allocated to the layers in this Supplement, based on the ITU-T technology watch report and FG SWM contributions.

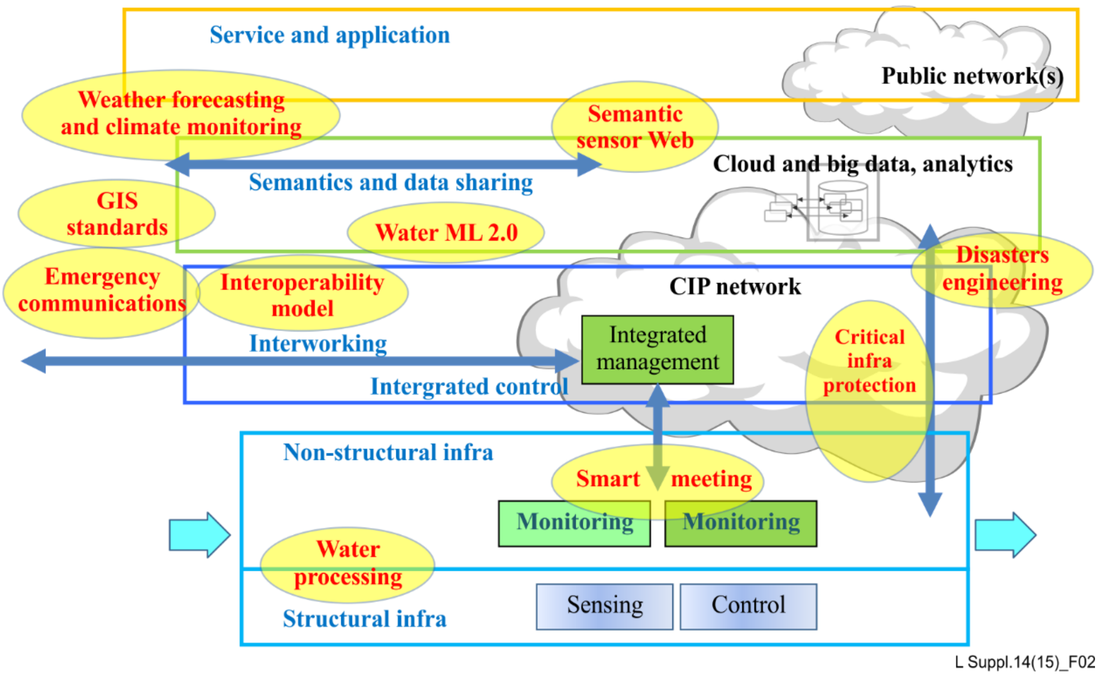

Figure 2 – Domains of standardization in SWM model

5 Standardization for service and application

5.1 Climate change and weather monitoring for forecasting

The World Meteorological Organization (WMO) is a specialized agency of the United Nations. WMO and its predecessor, the International Meteorological Organization, have supported National Hydrological Services, River Basin Authorities and other institutions responsible for water management in a wide range of activities. Presently, the hydrology and water resources programme (HWRP) is concerned with the assessment of the quantity and quality of water resources, both surface and groundwater, in order to meet the needs of society, to permit mitigation of water-related hazards, and to maintain or enhance the condition of the global environment. It includes standardization of various aspects of hydrological observations and the organized transfer of technologies that will enable hydrological services to provide the hydrological data and information required for the sustainable development of their countries. It provides advice to members on flood management policy and assists them in their effort to adopt Integrated Water Resources Management (IWRM) with an emphasis on practical applications. The programmes include [swm-i-25]:

– programme on basic systems in hydrology;
– programme on hydrological forecasting for water resources management (HFWR);
– programme on capacity building in hydrology and water resources management (CBH).

The WMO information system (WIS) is the single coordinated global infrastructure responsible for the telecommunications and data management functions. It provides an integrated approach suitable for all WMO programmes to meet the requirements for routine collection and automated dissemination of observed data and products, as well as data discovery, access and retrieval services for all weather, climate, water and related data produced by centres and member countries in the framework of any WMO programme.

Also, WMO has cooperated closely with the Open Geospatial Consortium (OGC) in the development of the WaterML 2.0 hydrological data exchange format, and is in the process of examining the possibility of adopting WaterML 2.0 as a WMO standard. [swm-i-25].

GEO (Global Earth Observation, http://www.earthobservations.org) was formally established at the Third Earth Observation Summit in February 2005 to carry out the global earth observation system of systems (GEOSS) 10-Year Implementation Plan. GEOSS (Global Earth Observation System of Systems, http://www.geoportal.org) publishes earth observation datasets from 92 member countries. CEOS (Committee on Earth Observation Satellites, http://waterportal.ceos.org) improved the accessibility to GEOSS through closer integration with the Discovery and Access Broker. The portal was specially designed for water domain resource discovery.

In USA, NASA provides global land data assimilation system (GLDAS) to share soil moisture information in the form of grids to generate time series data for discrete locations over the world. It can give a global soil moisture map (gridded data) with overlaid time series below for two selected locations.

5.2 Geographic information system

GIS technology requires interoperability. At the heart of the GIS lies its ability to analyse and integrate geographic information from many different sources and organizations. Development of standards in the area of GIS could set new trends and applications for managing water resources and the water distribution network system. The Open Geospatial Consortium (OGC, http://www.opengeospatial.org) is an international voluntary consensus standards organization which is involved in the development of standards for geospatial contents and location based services. OGC standards and specifications are technical documents that detail interfaces or encodings to address interoperability challenges. One of the specifications defined by the OGC, the geography markup language (GML), is an XML based language to express geographical features, is also an ISO standard (ISO 19136:2007).

The Geospatial Portal Reference Architecture developed by the OGC provides the basis for an open, vendor-neutral portal that is intended to be a first point of discovery for geospatial content in the context of designing and implementing the spatial data infrastructures being developed by over 50 nations throughout the world . The Geospatial Portal Reference Architecture is based on a Service Oriented Architecture (SOA). [TWR2010].

OGC has worked on Internet standards for map services, observation services and catalogue services; especially a water ML standard was developed thanks to the efforts from the Hydrology Domain Working Group, a venue for seeking technical and institutional solutions to the challenge of describing and exchanging data describing the state and location of water resources, in coordination with WMO, both above and below the ground surface.

6 Standardization for semantics and data sharing

6.1 Water ML

The WaterML2.0 is an extensible schema for exchange of data, which has the core aspect of "precise description of time series data (on geospatial water information)", based on OGC/IOS observation and measurements standards. It consists of UML model, XML schema (GML compliant), specification document, XML schematron rules, and vocabulary definition. [smw-i-10] WaterML 2.0 part 1 is implementing time series data and part 2 is going to touch ratings, gauging and cross sections for determining flow volume as function of stream depth and streamed conditions. The part 1 consists of two sub-parts as followings to define UML-style implementation agnostic information model, and to implement GML compliant XML schema on the top of it.

– A conceptual UML model for observational data as a profile as ISO19156. Observations & Measurements;
– An implementation of the model in XML Schema, specifically a GML 3.2 conformant XML Schema. [smw-i-10].

Since 2005, Consortium of Universities for the Advancement of Hydrologic Science Inc (CUAHSI, http://www.cuahsi.org), under the umbrella of the Hydrologic Information System (HIS) project, has developed a variety of web services providing access to large repositories of hydrologic observation data, including the USGS National Water Information System (NWIS), and the US Environmental Protection Agency's STORET (Storage and Retrieval) database of water quality information in the US. However, as the number and heterogeneity of data streams to be integrated in CUAHSI's hydrologic data access system increased, it became more and more difficult to maintain the system. Water ML was developed to provide a systematic way to access water information from point observation sites.[TWR2010].

For WMO has announced a vision on global sharing and open access to water information, GEOSS has identified 9 SBAs (societal beneficial area) including water area as one of them, and executed AIP (Architectural Implementation Pilot) since 2007. The subject of AIP-6 (2013) was "water data sharing easier" to link the water data in the regions and countries to common information model & service architecture. In between November 2009 and January 2010, WMO agreed an MoU with OGC, to enhance the development and use of geospatial standards. Following this, the OGC hydrology domain working group was set up jointly with WMO to work on the standardisation of hydrological data sets. This also included aligning the initial Water ML specification from CUAHSI with GML. After the work for 4 years in the group, the result of WaterML2.0 was released in 2013.

The Water Data Transfer Format (WDTF) Standard project is a key component of the Water Information Research and Development Alliance (WIRADA) in Australia. WDTF is an interim data encoding standard based on the OGC Observation and Measurements (O&M) standard data encoding and is closely linked to Australian statutory requirements and regulations for exchanging water information. The Australian Bureau of Meteorology is also co-sponsoring the development of Water ML 2.0 through its research agreement with the commonwealth scientific and industrial research organisation (CSIRO). The Australian Bureau of Meteorology and CSIRO are contributing to the work being done at the level of the OGC hydrology domain working group on Water ML 2.0[WDTF].

6.2 Semantic sensor web and platforms

The lack of standardized communications and application program interfaces (API) among the sensor networks is an issue which standardization activities at the OGC and Semantic Web Activity of the World Wide Web Consortium (W3C) are trying to address.

The OGC has established Sensor Web Enablement (SWE) by developing a number of specifications related to sensors, sensor data models, and sensor Web services that will enable sensors to be accessible and controllable via the Web [SSW2008].

In the W3C standardization work, the semantic web is an extension of the World Wide Web in which the semantics of information on the web are formally defined. Formal definitions are captured in ontologies, making it possible for machines to interpret and relate data content more effectively. The main technologies of the Semantic Web include the resource description framework (RDF) data representation model and the ontology representation languages RDF schema and web ontology language (OWL) [SSW2008].

The OGC is also working closely with the Internet Engineering Task Force (IETF) Geographic Location/Privacy (GEOPRIV) Working Group on the development on Internet standards for Uniform Resource Identifiers (URI) for Geographic Locations. The GEOPRIV working group is focused on developing and refining representations of location in Internet protocols, and to analyse the authorization, integrity, and privacy requirements that must be met when these representations of location are created, stored, and used. [TWR2010].

Sensor data is encoded based on spatial, temporal and thematic metadata which can be regarded as the "context information" in light of semantics view point. In order to handle the interworking issues in this level of heterogeneity, semantics platforms for integrated management are being suggested.

FP7 project WatERP (FP7-GA:318603) has dealt with it, to propose to connect among themselves subsystems that are consuming, managing or producing water, and which nowadays rely on separate solutions. It comprise both information architecture and intelligent infrastructure to link different management tools through a specific SOA-MAS architecture; based on standardized web services and multi-agents that perform match making orchestration.

7 Standardization for interworking and integrated control

7.1 Emergency communication

Emergency communication is crucial for government and humanitarian aid agencies involved in rescue operations, medical assistance and rehabilitation. ITU provides a wide range of activities across the study groups related to this field [ITU-ET].

Typical communication standards for public safety and disaster relief has been narrowband PPDR (Public Protection and Disaster Relief) which has been recommended by ITU's World Radiocommunication Conference (WRC) in its Resolution 646 (2003), for the use of common frequency for emergency communication. Typical technologies widely used are terrestrial trunked radio access (TETRA) in about 120 countries mostly in European region and Project 25 (P25) in USA.

WRC Resolution 646 is under revision for discussion at WRC 2015 including the issue of broadband PPDR. ITU-R WP5A, the working party leading the revision has developed a number of Recommendations, including M.2015 (frequency), M.2009 (technology), and M.2219 (IMT based PPDR), etc.

IEEE 802.16 Greater Reliability in Disrupted MAN (GRIDMAN) task group has examined access technologies between terminals, and the requirements for enhancing system reliability. Related requirements on Group Communication Systems has been taken by mobile service group Open Mobile Alliance (OMA) PTT over Cellular (POC) working group.

3rd Generation Partnership Project (3GPP), the leading standards development group for mobile communication, is developing PS-LTE (Public Safety –LTE) which is based on LTE technology to realize emergency communication. The specification focuses on device to device communication (D2D), ProSe (Proximity based Service), and Group Communication System Enabler (GCSE) IOPS (Isolated E_UTRAN Operation Public Safety) and MCPTT (Mission Critical Push to Talk), etc. Those will be developed aiming to be packaged as Release13 of their work plan.

7.2 Critical infrastructure protection and disaster engineering

Critical Infrastructure Protection (CIP) is implemented in USA as American Presidential directive PDD-63 of May 1998 that sets up a national program of CIP. In Europe the equivalent "European Programme for Critical Infrastructure Protection" (EPCIP) refers to the doctrine or specific programs created as a result of the European Commission's directive EU COM (2006) 786 which designates European critical infrastructure that, in case of fault, incident, or attack, could impact both the country where it is hosted and at least one other European Member State. Member states are obliged to adopt the 2006 directive into their national statutes.

In the deployment of SWM/SWG, the new systems based on meters and sensors, communication infrastructure, and information system are all generally critical assets in light of national or social infrastructure, thus the adequate care for the design, implementation and operation of the system should be applied while considering related regulations. For the networking aspect, specialized zoning concept can be applied to establish a secure industry network that supports reliable operation of the water management system while also providing open communication with cyber security as specified in [ISO/IEC 27001].

This concern is also applicable to the cases of hazard avoidance, disaster relief and system resiliency, in relation to systems capable of addressing these cases. Basically the separated considerations for prevention, provisioning, correspondence, restoration, and more means should be devised. Emerging ICT issues related to it are as follows;

– advanced risk assessment based on big data processing for climate information;
– precise prediction of climate change and weather forecast;
– information sharing and integrated management for disaster case;
– closer interaction with citizens' activity and the information in case of disaster.

7.3 Interoperability model

As smart (power) grids interconnect local electrical networks that have been upgraded to smart grids relying on a high capacity backbone of electric power transmission lines, an interoperability model was required to accelerate the implementation of interoperable smart grid devices and systems.

Smart grid interoperability panel (SGIP) is a non-profit organization established in December 2009 by the U.S. National Institute of Standards and Technology (NIST) as a public-private partnership, to support the work behind power grid modernization through the harmonization of technical interoperability standards to advance grid modernization. SGIP's stakeholders include utilities, manufacturers, consumers and regulators, and SGIP coordinates and collaborates with them end-to-end across the Smart Grid enterprise and furthers interoperability by developing reference architectures and facilitating/harmonizing the standards development.

A list of key stakeholders of SWM, required to start the modelling of interoperability reference architecture, is provided by ITU-T report on "Partnering for solutions: ICTs in Smart Water Management". The report categorizes the stakeholders in three groups:

– Stakeholders who have influenced "ICTs and smart water management": This group is leading the way in the development of SWM solutions, products and tools and comprises ICT corporations and organizations, scientists/academia and research groups, as well collaborations with businesses, the industry, corporate entities and non-governmental organizations (NGOs).
– Stakeholders who have a direct impact on "ICTs and smart water management": This group directly affects or is affected by policies related to the water sector and therefore have a major part to play in the implementation of SWM programs within countries. This includes international governmental organizations, governments, municipalities, water authorities and water managers, as well as regulators on water issues and the environment in local, regional, national and international levels.
– Stakeholders who have an indirect impact on "ICTs and smart water management": This group will be addressed in successive reports. [ITU-T 2014].

8 Standardization for water management infrastructure

8.1 Smart metering, AMI

Smart meters, AMI and AMR have generated a lot of interest in the past few years. One of the driving forces has been the EU Directive on energy end-use and energy services, together with market liberalization and a general trend for energy saving and environmental concern by consumers. This has created a demand for interoperable solutions for meter reading, and a unified approach for the different media (electricity, gas, heat and water).

The open metering system specification (OMS) was the first definition designed to acquire data on electrical energy, gas and water consumption in households and businesses and has been developed jointly by industry associations FIGAWA (German Gas and Water Industry Association), KNX

Association and ZVEI (the German Electrical and Electronic Manufacturer's Association). The objective is to develop a complete solution for AMR/AMI as well as standardise smart meter reading devices. The proposal has already been submitted to the European Committee for Standardisation (CEN) with the goal to establish it as pan-European standard. It includes the EN 13757 standard for the data transmission between smart meter and data concentrator.

The specification describes how the data from the meters is to be transmitted from the meter to the authority's back office system in a secure manner. A multi utility communication device (MUC) which can be either integrated in the meter or implemented as a separate device (in case of buildings and apartments) acts as an intelligent data concentrator between the automated meter management (AMM) back office system and the metering device. The specification splits communication between meters and back office into primary, secondary and tertiary communication. Primary communication is between the meter and the MUC and is based on the M-Bus standard (EN-13757). The secondary communication is an extension of the primary communication using repeaters or a multi-hop routing protocol. Proprietary solutions are allowed as for the secondary communication, as no unified network protocol is yet specified.

Communications between the MUC device and the AMM back office (i.e., the water/electricity authorities) is based on TCP/IP. The specification takes into account the issue of data protection and data security. The advanced encryption standard (AES) 128 bit encryption standard is used to secure the privacy of the consumer to prevent unauthorised reading of the meter data, as well as preserving the integrity of the data for the utility company and from fraud by replay of old messages. The power consumption of the communications subsystem is usually the biggest consumer of the battery current. The specification defines a radio protocol for the communications system that allows for battery lifetime for more than 14 years [TWR2010].

8.2 ISO/IEC for water processing

Water management system basically includes the treatment and distribution process that are similar to a certain transportation business or a production and delivery line process; that assumes the operation company is to be at the centre of the process as the key actor, and the standards for the technology can be easily classified as "industry standards" mostly being developed in ISO or ISO/IEC JTC1. Those standards are still effective in SWM or SWG, while incorporating ICT technology as its innovation drivers. The industry standards focusing on supply system and the processing over it have been released much in the groups listed as follows:

1) TC 5: Ferrous metal pipes and metallic fittings;
2) TC23/SC18: Tractors and machinery for agriculture and forestry;
3) TC30: Measurement of fluid flow in closed conduits;
4) TC113: Hydrometry;
5) TC138: Plastics pipes, fittings and valves for the transport of fluids;
6) TC147: Water quality;
7) TC153: Valves;
8) TC207/SC5: Environmental management;
9) TC211: Geographic information/Geometrics;
10) TC224: Service activities relating to drinking water supply systems and wastewater systems – Quality criteria of the service and performance indicators;
11) TC 282: Reusing the water resources;
12) IWA 6:2008: ISO International Workshop Agreement : Crisis situations;
13) PC253: Treated wastewater reuse for irrigation.

8.3 Others

Some topics in CIP/CIN are applicable also to the water infrastructure level.

9 Gap analysis

The idea developed through the researches in previous sections is mainly on the categorization of standardization activities in SDOs. Since the smart water management is in the emerging stage, the activities are generally focusing on a specific part of technical innovation or realization omitting to provide the general and entire architecture of SWM. Most of existing realization is for providing hydrological service and data sharing, as such implementations of Web based information systems.

Table 1 shows the fragmented activities of the SDOs mapped to the structure of general architecture given in Figure 2, and evaluates what type of standards activities and documents they are working on, and how these should be used for SWM. Packaging the information will create a "catalogue of standards" for SWM in the structure of standard architecture, and combining it with the "stakeholders/actors model" will provide a firm basis to develop the interoperability model/profile which is the priority for the standardization of SWM.

Table 1 – Relevance of the activities of identified organizations to the standardization of smart water management

Architectural categories	Technical area	SDOs involved in the area	The SDO's documents or activities	Document/activities' objectives	Standardization types related to the documents/activities					Standardization issues (gaps) related to the area
					Pre	Req	Arc	Pro	Other (s)	
Service and application	Weather forecasting and climate monitoring	WMO	HWRP (programmes)	Help assessment of quantity and quality of water resource	O	O	O		Progr-ammes	This programme includes the standardization of various aspects of hydrological observation and organized transfer of technology for enabling hydrological services. It provides basic system aspect and hydrology, forecasting, and resource management. This contents would be a good reference for developing service and system requirement on smart water management
			WIS (information system)	Collection and dissemination of water data	O	O			System	This system provides a good practice of water data collection and dissemination. It will impact the data sharing standardization

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					Pre	Req	Arc	Pro	Other (s)	
		GEO	GEOSS/CEOS (portal service)	Water domain resource discovery	O	O			Service	Incorporating this service into SWM is to be a mandate
		NASA	GLDAS (service)	Global soil moisture map	O	O			Service	Incorporating this service into SWM is to be a mandate
	Geographical Information System	OGC	GML / ISO 19136:2007	language to express geographical features				O		Together with WML, this standard will contribute general interoperability of SWM
Big data, semantics and data sharing	Water ML	OGC/ISO	Water ML 2.0 part 1, ISO 19156	Water data sharing /inter-operability	O	O	O	O		So far this standard is the best practice to provide interoperability of water systems
		WIRADA	WDTF	Water data sharing /inter-operability	O	O	O	O		Cooperating WaterML2.0
	Semantics Sensor Web, and platforms	OGC	SWE	Enable sensors applications via the Web	O	O	O	O		Connecting sensor data to Web service will give versatility to utilize sensor's context in an application
		IETF	GEOPRIV	URI for geographic location	O	O	O	O		The representations of location in Internet

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					Pre	Req	Arc	Pro	Other (s)	
										protocols will make advances in location based smart service
		W3C	RDF/OWL	Resource description/ Web ontology	O	O	O	O		Applying this dominant description method to water management would be one of biggest challenge to make it smart.
		WatERP/ FP7	Semantics platform	Water management with sematic data	O	O	O			It will link different management tools through a specific SOA-MAS architecture; via web
Integrated control and interworking	Emergency Communication	ITU	WRC646 / Narrowband PPDR	Use of TETRA & P25	O	O	O			Emergency communication is crucial for government and humanitarian aid agencies involved in rescue operations, medical assistance and rehabilitation. For SWM, emergency communication should be provided to assist control and supervisory system of water management, and to assists disaster
		ITU-R WP5A	Broadband PPDR M.2015 M.2009 M.2219	Frequency Technology IMT based PPDR		O O O	O			
		IEEE	802.16	Direct communication between terminals	O	O				

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					Pre	Req	Arc	Pro	Other (s)	
			GRIDMAN							management related to water
		OMA	POC	PTT over cellular		O	O	O		
		3GPP	PS-LTE	D2D(device to device), ProSe (Proximity based service), GCSE (Group communication), IOPS (isolated E-UTRAN for public safety), MCPTT(mission critical PTT)	O	O	O	O		
	Disaster Engineering and Critical Infrastructure protection	NIST	SP-800-53 SP-800-82	Information security for industry network, SCADA & industrial control system security	O O	O O	O O			These standards, regulation, and guidelines are indispensable to design, implement, and operate the critical infrastructure and its network . SWM system should be realized as a CIP by applying this technology.
		NERC	CIP 001-4 ~009-4	Reliability/ Security measures for CIP	O	O	O			
		NRC	10CFR 73.54 & RG5.71	Cyber security for CIP	O	O	O			
		ISA	ISA-99 FR1~FR7	Industrial control security	O	O				

Table 1 – Relevance of the activities of identified organizations to the standardization of smart water management

Architectural categories	Technical area	SDOs involved in the area	The SDO's documents or activities	Document/activities' objectives	Standardization types related to the documents/activities					Standardization issues (gaps) related to the area
					Pre	Req	Arc	Pro	Other (s)	
		ISO	IWA6:2008	ISO International Workshop Agreement: Crisis situations						This agreement should be considered for SWM in conjunction with emergency telecommunication
	Interoperability Model	NIST/SGIP	PAP	Identifying priority issues & action plan for interoperability of smart grid	O	O				This plan and catalogue of standards are urgently required to develop in the standardization of SWM by identifying actors and domains in it
		ITU-T	Report on ICTs and smart water management	Categorization of stakeholders	O					This paper can be utilized to identify stakeholders in SWM, to develop actor model of it.
Water management Infrastructure	Smart metering, AMI	CEN (OMS/FIGAWA/KNX/ZVEI)	EN13757	Data transmission between smart meter and data concentrator.		O	O	O		Since AMI and AMR would be a kind of essential tools in SWM, this standards should be incorporated in the catalogue of standards
	Water processing	ISO/IEC	TC 5	Ferrous metal pipes & metallic fittings		O				These industrial standards are considered as the

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					Pre	Req	Arc	Pro	Other (s)	
			TC23/SC18	Tractors and machinery for agriculture and forestry		O				underlying technology of SWM
			TC30	Measurement of fluid flow in closed conduits		O				
			TC113	Hydrometry		O				
			TC138	Plastics pipes, fittings and valves for the transport of fluids		O				
			TC147	Water quality		O				
			TC153	Valves		O				
			TC207/SC5	Environmental management		O				
			TC211	Geographic information/ Geometrics		O				
			TC 282	Reusing the water resources		O				
			PC253	Treated wastewater reuse for irrigation		O				

Table 1 – Relevance of the activities of identified organizations to the standardization of smart water management

Architectural categories	Technical area	SDOs involved in the area	The SDO's documents or activities	Document/activities' objectives	Standardization types related to the documents/activities					Standardization issues (gaps) related to the area
					Pre	Req	Arc	Pro	Other (s)	
			TC224	Service activities relating to drinking water supply systems and wastewater systems – Quality criteria of the service and performance indicators		O				

Pre: Pre-standard: Study on Eco-system, Use cases, Feasibility, etc.
Req: User requirement, System requirement
Arc: Architecture
Pro: Protocol

10 Priority areas and suggestions to ITU-T SG 5

ITU-T SG 5 is advised to focus on the following architectural categories identified in this technical report. These are service and application, big data/semantics and data sharing, integrated control and interworking, and water management infrastructure.

Priority areas for future standardization work should focus on studies on eco-system, interoperability models, architectural framework and feasibility of the technologies that are foreseen to be applicable in the SWM ecosystem.

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