

TECHNICAL REFERENCE

Sensor networks for Smart Nation (homes)



Published by

Enterprise
Singapore

TR 40 : 2015

(ICS 35.110; 35.240.01)

TECHNICAL REFERENCE

Sensor networks for Smart Nation (homes)

All rights reserved. Unless otherwise specified, no part of this Singapore Standard may be reproduced or utilised in any form or by any means, electronic or mechanical, including photocopying and microfilming, without permission in writing from SPRING Singapore at the address below:

Standards
SPRING Singapore
1 Fusionopolis Walk,
#01-02 South Tower, Solaris
Singapore 138628
Email : standards@spring.gov.sg

ISBN 978-981-4557-81-8

First published, 2015

NOTE

1. *Singapore Standards (SSs) and Technical References (TRs) are reviewed periodically to keep abreast of technical changes, technological developments and industry practices. The changes are documented through the issue of either amendments or revisions.*
2. *An SS or TR is voluntary in nature except when it is made mandatory by a regulatory authority. It can also be cited in contracts making its application a business necessity. Users are advised to assess and determine whether the SS or TR is suitable for their intended use or purpose. If required, they should refer to the relevant professionals or experts for advice on the use of the document. Enterprise Singapore shall not be liable for any damages whether directly or indirectly suffered by anyone or any organisation as a result of the use of any SS or TR.*
3. *Compliance with a SS or TR does not exempt users from any legal obligations.*

Contents

	Page
Foreword _____	5
0 Introduction _____	7
1 General _____	10
2 Normative references _____	11
3 Terms and definitions _____	12
4 Abbreviations _____	14
5 Conventions _____	15
6 Sensor networks for homes _____	15
7 Core requirements of sensor network framework for homes _____	22
8 Overview of sensor network architecture _____	24
9 Recommendations _____	29

Annexes

A Communications standards _____	48
B Examples of sensor network applications for homes _____	50

Tables

1 Four aspects of a data and control interface _____	30
2 Recommended standards for backhaul network _____	30
3 Recommended standards for wired sensor networks _____	31
4 Recommended standards for wireless sensor networks _____	32
5 Recommended standards for data and control interface _____	33
6 Recommended standards for industry-specific interfaces _____	35
7 Recommended standards for the management of gateways and platforms _____	36
8 Security levels for MAC sub-layer _____	38
9 Security modes available for Bluetooth BR/EDR _____	40
10 Security modes available for Bluetooth Low Energy (LE) _____	41
B.1 Relevant interfaces in a home automation scenario _____	51
B.2 Relevant interfaces in a multi-network with WAN connection _____	52

Figures

1 Smart Nation possibilities _____	9
2 Boundary of a home sensor network _____	16
3 Potential applications of sensor networks for homes _____	17
4 System view of sensor networks for homes _____	18
5 Various configurations for home sensor networks _____	19

	Page
6	Sensor network functional architecture _____ 24
7	Interfaces for standardisation within sensor network framework _____ 26
8	Interfaces within sensor network service framework _____ 27
9	Scope of security controls _____ 28
B.1	Data and control interfaces used in home automation scenario _____ 50
B.2	Data and control interfaces used in in-home healthcare scenario _____ 52
	Bibliography _____ 53

Foreword

This Technical Reference (TR) was prepared by the Sensor Network Working Group (SNWG) of the Internet of Things Technical Committee (IoT TC), under the direction of the IT Standards Committee (ITSC). The ITSC endorsed the TR on 4 March 2015.

According to ISO/IEC 29182-2[4], sensor networks are systems of spatially distributed sensor nodes interacting with each other and, depending on applications, possibly with other infrastructure. The primary functions of sensor networks are to acquire, process, transfer, and provide information extracted from its environment to enable detailed reporting and in some cases, provide control capability. Sensor networks can be broadly classified into two categories. In the first category, sensors or sensor nodes are densely deployed in a mesh formation with multi-hop radio connectivity in an outdoor environment. Environment monitoring and control systems typically belong to this category. The other kind of sensor networks generally employs star-based topology with single hop radio connectivity in a more confined environment. Home and building control systems are examples of sensor networks in this category.

With the launch of Singapore's Smart Nation initiative, sensor networks are expected to proliferate in homes with the increasing ubiquity of connected devices. The scalability of such sensor networks however, will be affected by the absence of standards that address system architecture and security concerns.

The implications of deploying sensor networks in homes are not fully understood as it requires multi-disciplinary expertise. Sensor networks for homes will need to evolve and develop as public agencies and industries gain more deployment and operational experience. Hence this TR is expected to also evolve with time.

This Technical Reference is not to be regarded as a Singapore Standard. This Technical Reference is made available for provisional application over a period of two years, but does not have the status of a Singapore Standard. The aim is to use the experience gained to modify the Technical Reference so that it can be adopted as a Singapore Standard. Users of the Technical Reference are invited to comment on its technical content, ease of use and any ambiguities or anomalies. These comments can be submitted using the feedback form provided at the end of the Technical Reference and will be taken into account in the review of the publication. At the end of the two years, the Technical Reference will be reviewed by the WG to discuss the comments received and to determine its suitability as a Singapore Standard. Submission for approval by the Standards Council as a Singapore Standard will be carried out only upon agreement after review.

NOTE – Due to changes in the industry landscape, this Technical Reference may be revised earlier than the typical two-year review period if deemed necessary.

This Technical Reference will help system integrators, technology developers and service providers in the design and implementation of solutions for home sensor networks.

In preparing this Technical Reference, reference was made to the following publications:

- 1) ISO/IEC 29182-1:2013 Information technology – Sensor networks: Sensor Network Reference Architecture (SNRA) – General overview and requirements
- 2) ISO/IEC 29182-2:2013 Information technology – Sensor networks: Sensor Network Reference Architecture (SNRA) – Vocabulary and terminology (which Clause 3 of this Technical Reference is largely based on)
- 3) ISO/IEC 29182-3:2014 Information technology – Sensor networks: Sensor Network Reference Architecture (SNRA) – Reference architecture views
- 4) IEEE 802.15.4-2011 Low-Rate Wireless Personal Area Networks (LR-WPANs), Table 58

5) Bluetooth Core Specification 4.0 information on Security Modes

Acknowledgement is made for the use of the above publications.

Attention is drawn to the possibility that some of the elements of this Technical Reference may be the subject of patent rights. Enterprise Singapore shall not be held responsible for identifying any or all of such patent rights.

Technical Reference for sensor networks for Smart Nation (homes)

0 Introduction

0.1 Smart Nation vision

Singapore is implementing a bold plan to become the world's first smart nation in an effort to improve the lives of its residents. Singapore hopes to develop a new technology industry through the Smart Nation implementation which will nurture creative talent in data and analytics, aid development of impactful applications and disruptive technologies, ranging from smart robotics, Internet of Things (IoT) to big data, cloud computing, etc. At the same time, the nation is also integrating efforts across different agencies to share and protect data while paying particular attention to data governance and cyber-security. The end goals are to build an anticipatory government, provide an array of city services and empower citizens with rich data insights to improve lives. It is doing so by leveraging its effective and open access fibre network to homes and offices and by expanding the intelligent infrastructure to street level coverage with new Aggregation Gateway Boxes (AG Boxes) for an integrated sensor-rich network, together with a new Smart Nation Operating System. At the same time, it is exploring a new Heterogeneous Network (HetNet) across fixed and mobile infrastructures.

As shown in Figure 1, potential themes of Smart Nation are:

- Integrated city planning — use geospatial analytics to enrich experience and predict where amenities are needed;
- Integrated public services — provide one-stop service with anticipatory and interconnected infrastructure;
- Healthcare — enable tele-monitoring and tele-rehab services;
- Safety and security — provide non-intrusive, real-time smart monitoring systems;
- Urban mobility — enable development of innovative mobile solutions to optimise travel experience; and
- Urban living — build connected homes, leveraging smart home technologies.

A critical role of Information and Communication Technology (ICT) standards is to enable the integration and interoperability of different ICT systems that support Smart Nation initiatives. This will facilitate the optimal use of resources across these systems in order to provide value to Singapore as a whole as well as to each individual citizen.

0.2 Objectives

As shown in Figure 1, there are six possible Smart Nation initiatives. Sensor networks are one of the key technologies that support Singapore's vision to be a smart nation. Two of the Smart Nation initiatives - urban living and healthcare - are likely to involve large deployments of various kinds of sensor devices at homes. They provide the means to gain better awareness of situations and activities in homes through the sensor data collected, to make decisions in real time - as events or emergencies occur, or to develop appropriate services that will result in more responsive, anticipatory services for the citizens.

It follows that sensor networks in the homes are expected to proliferate with the increasing ubiquity of connected devices. However, the absence of a common standards-based architecture for such sensor network solutions in homes affects the scalability of sensor networks at home. Other issues that arise from the lack of a common standards-based architecture include:

- affordability — costs of wireless sensor devices remain elevated and are a significant addition to the base connectivity and associated infrastructural costs;
- market entry — opportunities for business development and further innovation are constrained by proprietary deployments; and
- security — concerns over security stymie the sharing of sensor data that drives development of innovative applications and services.

This TR aims to help industry design and provide better services to make Singapore smarter, more liveable and more environmentally friendly. It intends to achieve this by providing a set of core requirements for the sensor network framework and a set of recommended communication and interface standards for sensor networks for homes, so as to:

- improve the interoperability of sensor networks for homes;
- promote sharing of sensing data and sensor network infrastructure;
- reduce the cost of deploying, operating and maintaining sensor applications; and
- ease the development of innovative applications utilising sensor data.

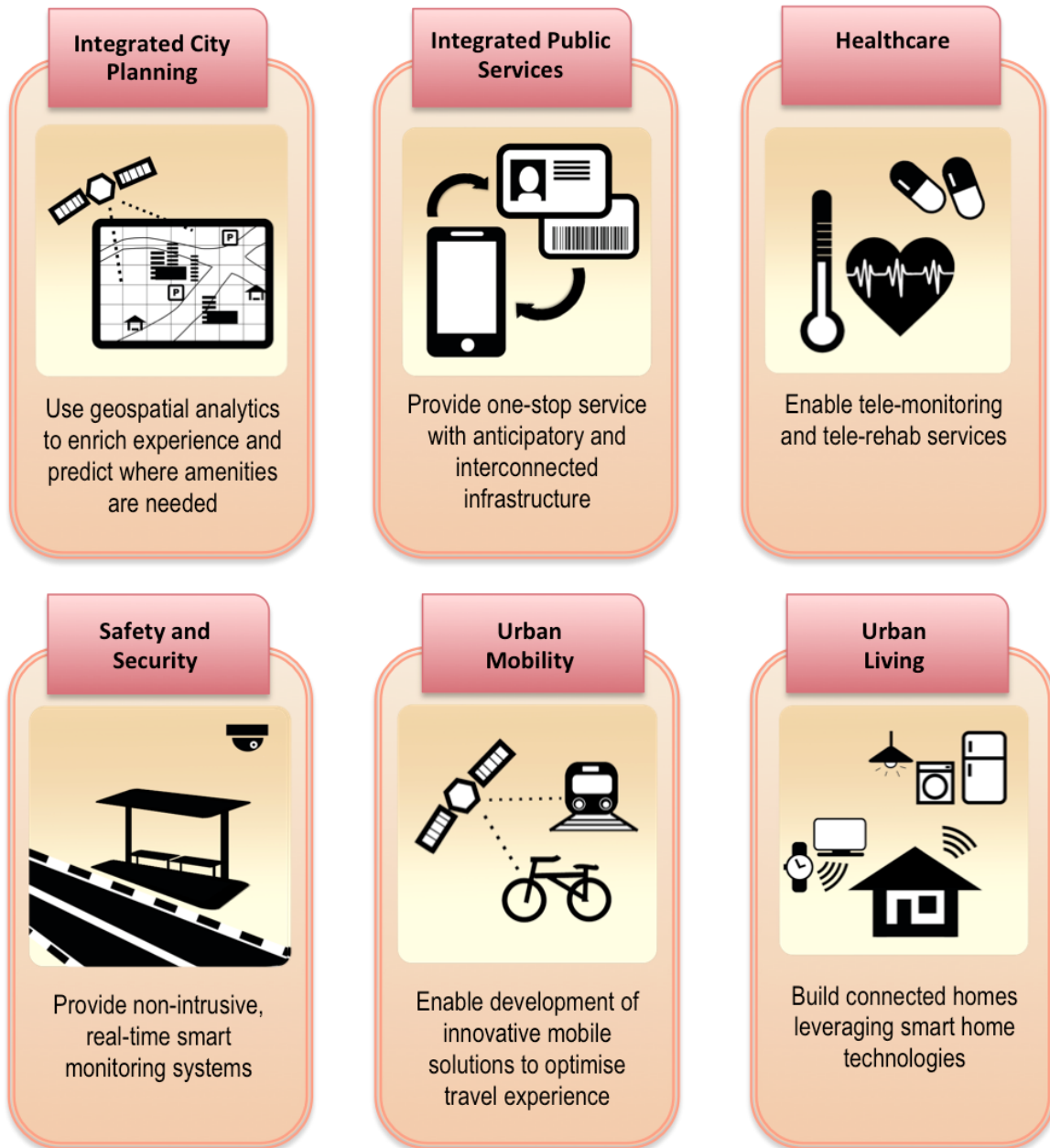


Figure 1 – Smart Nation possibilities

1 General

1.1 Scope

1.1.1 This TR provides the framework and a minimum set of communication and application interface standards for the development and deployment of sensor networks for homes in Singapore. It covers the following areas:

- (a) a set of core requirements for sensor network framework for homes which enables the provision of services for Smart Nation;
- (b) a minimum set of coherent international or industry standards for interface interoperability for the various functional layers of the sensor networks for homes that supports a variety of applications across multiple agencies and industries and is suitable for deployment on a national scale:
 - (i) wired and wireless protocols between home sensor gateway and devices;
 - (ii) home sensor gateway and sensor network integration platform;
 - (iii) sensor network integration platform and sensor applications; and
 - (iv) security considerations and recommended security controls for home sensor networks.

Adopting a common set of communication, application interface and information security standards for the sensor network will facilitate the interoperability of the devices and sensors from different manufacturers.

1.1.2 The following are not within the scope of this TR as it:

- is not a smart home deployment guide for setting up home sensor networks (i.e. not a how-to guide);
- is not a functional specification for services (e.g. data fusion, data modelling, data exchange) to be provided by sensor networks for homes for Smart Nation;
- does not recommend a specific commercial application toolkit or framework to setup home sensor networks;
- does not attempt to list all requirements and applicable scenarios to build a smart home;
- does not attempt to improve or resolve disparities or shortcomings among transmission, technologies, protocols, or application languages;
- does not define the roles and responsibilities of the parties involved in setting up, utilising or managing the home sensor networks or mandate which party should take ownership of the day-to-day operations and maintenance (including security) of the networks;
- does not address potential attacks using sophisticated electromagnetic jamming or interference techniques; and
- does not address security controls for public, regulated telecommunications networks.

1.2 Audience

Various parties may use the recommendations stipulated in this document in the following ways:

- agencies and service providers who want to deliver home sensor network infrastructure and common services should consider the recommendations in Clause 9 when designing and implementing the services;
- industry players or application developers who want to develop devices or applications for home sensor networks should consider the recommendations in Clause 9 when designing devices and/or implementing the services; and
- end-users who are technically savvy may refer to this document when selecting devices or service providers, or when setting up their home network to ensure that best practices are complied with.

2 Normative references

The following referenced documents are indispensable for the application of this TR. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced documents (including any amendments) applies.

BBF TR-069	CPE WAN Management Protocol, Broadband Forum
Core Version 4.0	Bluetooth Core Specification Version 4.0
ECMA 404, Oct 2013	JSON Data Interchange Format
IEEE 11073	IEEE 11073 Personal Health Data (PHD) Standards
IEEE 802.11	Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
IEEE 802.15.4-2011	Local and metropolitan area networks – Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)
IETF RFC 3411-3418	Simple Network Management Protocol (SNMP) version 3
IETF RFC 6120	Extensible Messaging and Presence Protocol (XMPP): Core
IETF RFC 7252 (June 2014)	The Constrained Application Protocol (CoAP)
ISO/IEC 29182-1	Information technology – Sensor network : Sensor network reference architecture (SNRA) – Part 1: General overview and requirements
ISO/IEC 29182-2	Information technology – Sensor network : Sensor network reference architecture (SNRA) – Part 2: Vocabulary and terminology
ISO/IEC 29182-3	Information technology – Sensor network : Sensor network reference architecture (SNRA) – Part 3: Reference architecture views
ISO/IEC 29182-4	Information technology – Sensor network : Sensor network reference architecture (SNRA) – Part 4: Entity models

ISO/IEC 29182-5	Information technology – Sensor network : Sensor network reference architecture (SNRA) – Part 5: Interface definitions
ISO/IEC 29182-7	Information technology – Sensor network : Sensor network reference architecture (SNRA) – Part 7: Interoperability guidelines
OASIS MQTT v3.1.1	OASIS MQ Telemetry Transport (MQTT) v3.1.1 Protocol Specification
ITU-T H.810 (12/2013)	Interoperability design guidelines for personal health systems
OGC SWE	Open Geospatial Consortium (OGC) Sensor Web Enablement framework standards
OMA Device Management 2.0	Open Mobile Alliance (OMA) Device Management Protocol v2.0
OMA Lightweight M2M (LWM2M) v1.0	Open Mobile Alliance Lightweight Machine to Machine Technical Specification
uPnP v2.x	Universal Plug and Play version 2.x
W3C EXI Recommendation 11, Feb 2014	Efficient XML Interchange (EXI) Format, 1.0 (Second Edition)