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## IPv6-based Industrial Internet leveraging 6TiSCH technology

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*ETSI*

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

# Contents


Intellectual Property Rights ........ 5
Foreword ........ 5
Modal verbs terminology ........ 5
Executive summary ........ 5
Introduction ........ 6
1 Scope ........ 7
2 References ........ 7
2.1 Normative references ........ 7
2.2 Informative references ........ 7
3 Abbreviations ........ 13
4 Converging Networks for the Industrial Internet ........ 15
4.1 On Operational Technology ........ 15
4.2 Enabling the IT/OT convergence ........ 15
4.3 The path to the IT/OT Convergence ........ 16
4.4 The case of Low-power Lossy Networks ........ 17
5 What is Deterministic Networking? ........ 18
5.1 Common definitions (from Web encyclopaedia) ........ 18
5.2 The train analogy (to control loop traffic) ........ 19
5.3 The bus analogy (to deterministic circuit switching) ........ 19
5.4 The vacation place analogy (to time-sharing) ........ 20
5.5 The casino analogy (to statistical effects) ........ 21
5.6 Transporting OT traffic ........ 22
6 Enabling Determinism in a Network ........ 22
6.1 The precursors ........ 22
6.1.1 On Fast Reroute ........ 22
6.1.2 On SDN and Traffic Engineering ........ 23
6.2 Expected benefits in wired networks ........ 23
6.3 Making Ethernet deterministic? ........ 24
6.4 Making wireless deterministic? ........ 24
7 The IETF DetNet architecture ........ 27
7.1 Positioning of work ........ 27
7.2 The architecture in a nutshell ........ 27
7.3 Networking in DetNet ........ 28
7.4 Controlling a Deterministic Network ........ 30
7.4.1 Reporting the topology to the controller ........ 30
7.4.2 Implementing the needs of the application ........ 31
7.4.3 Automating the network operation ........ 33
7.5 Limits and perspectives ........ 33
8 The art of low-power wireless sensor network ........ 33
8.1 A highly predictable wireless ........ 33
8.2 WSNs in Industrial Process Control ........ 35
8.3 6TiSCH and best effort IPv6 ........ 35
9 The vision of 6TiSCH centralized scheduling ........ 37
9.1 A converged wireless network ........ 37
9.2 PCE vs. 6TiSCH ........ 38
9.3 6TiSCH base elements (time slots, schedule, chunks and bundles) ........ 38
9.4 Applying DetNet to 6TiSCH ........ 43
9.5 Forwarding along 6TiSCH Tracks ........ 43
9.6 Enabling the convergence ........ 44

10 Conclusion........................................................................................................................45

**Annex A: Authors & contributors**..........................................................................................**47**

History ...............................................................................................................................48

# Intellectual Property Rights



# Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) IPv6 Integration (IP6).

# Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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# Executive summary

The Industrial Internet will enable deep process optimization in multiple industries by introducing Information Technology (IT) capabilities, such as Big Data and virtualization, to improve Operational Technology (OT) processes while reducing the OPEX, with the convergence of the IT and OT network. At the core of this revolution, a new breed of Deterministic Networks will provide enhancements that are required to fully emulate the traditional serial links and field buses that are widely deployed in that space over IPv6.

Deterministic Networking is a new (to IT networks) level of guarantee for network-based services, based on time, resource reservation, and enforcement. Deterministic Networking provides the capability to carry specified unicast or multicast data streams for real-time applications with extremely low data loss rates and bounded latency. Deterministic Networking technology allows for guarantees of 'worst-case' delivery. More precisely, the worst-case data loss and latency are guaranteed in a consistent fashion as multiple services are deployed on a common converged network infrastructure.

Deterministic Networking adds key capabilities to the Internet (wired, wireless, Layer 2 and Layer 3) to support time-sensitive mission-critical applications on a converged enterprise infrastructure. These capabilities are required to drive the connection of billions of things, and make available the vast amounts of data that IoE applications generate.

Deterministic Networking is a quantum step beyond existing QoS mechanisms. It implies time synchronization on all the nodes, often including source and destination, the centralized computation of the deterministic paths from a global perspective for a better optimization, new traffic shapers and schedulers within and at the edge to protect the network, and new hardware for time-triggered access to the media.

6TiSCH [i.107] enables Deterministic Networking over Low-Power Radios, controlled by a central intelligence called a PCE. At the same time, 6TiSCH allows traditional best effort IPv6 flows routed with the RPL routing protocol to utilize the portions of the bandwidth that are not allocated to deterministic flow. This way, the collection over IPv6 of traditionally unmeasured data can scale to vast numbers without interfering with the more critical flows for which all the necessary resources are reserved.

# Introduction

It all started with point-to-point copper wires, transporting analogue signals for short messages, then telephone and television, industrial measurements and commands, anything though initially not data. Digital data networks, and then packet networks, came last; but with the advent of determinism, the late comers now show the potential to federate all original forms of wired and wireless communication and lead to the final convergence of all communication networks.

A generic and cheap replacement to serial cables to provide connectivity to all sorts of devices, coupled with resource-sharing meshed networks, are now required to simplify the cabling and drive the costs down in many industries, from transportation to manufacturing. Simple as it may seem to emulate the legacy forms of serial communications, reproducing the various aspects of a point-to-point electric cable over a multi-hop packet network is actually the hardest thing to do. Yet, the need is becoming more and more pressing, as:

1) managing all the existing sorts of cables and buses has become an increasingly costly complexity in many aspects of our lives; and

2) point-to-point wires will not scale to serve the exploding needs of the Internet of Things.

A paper on "Integrating an Industrial Wireless Sensor Network with your Switched Ethernet and IP Network [i.67]" was presented at the Emerson Exchange 2008 conference in Washington. The paper discussed how Wireless Sensor Networks (WSNs), which are in essence cheaper and faster to deploy than traditional wired field-buses, could leverage the entire network to connect the sensors to a centralized controlling application located afar on the carpeted floor, for Industrial supervisory control or logging. At the same time, the paper stressed issues that are raised when integrating a classical, often proprietary industrial automation network, with tight response time and availability constraints, into a wider IP network based on packet-switched and Internet technologies. With this and a collection of other papers [i.69], [i.70], [i.71] and [i.72], the realization is now coming that with techniques such as flow isolation, high availability and a new generation of Quality of Service (QoS), the times of the convergence of these networks are finally approaching.

# 1 Scope

The present document outlines a general architecture for an Industrial Internet, providing motivation for the deployment, and some technical guidelines with a focus on deterministic and low power technologies, for a prospective IPv6-based Industrial Internet leveraging deterministic wireless technology. The present document elaborates on deterministic networking, wired and wireless, for application in the Industrial Internet.

# 2 References

## 2.1 Normative references

Normative references are not applicable in the present document.

## 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.


[i.1] IETF RFC 6371: "Operations, Administration, and Maintenance Framework for MPLS-Based Transport Networks".

[i.2] J. Araujo et al.: "High availability automation networks: PRP and HSR ring implementations" in: Industrial Electronics (ISIE), 2012 IEEE International Symposium on, IEEE, 2012, pp. 1197-1202.

[i.3] IETF RFC 7471: "OSPF Traffic Engineering (TE) Metric Extensions".

[i.4] D. Beller and R. Sperber: "MPLS-TP-The New Technology for Packet Transport Networks" in: DFN-Forum Kommunikationstechnologien, vol. 149, 2009, pp. 81-92.

[i.5] IETF RFC 6119: "IPv6 Traffic Engineering in IS-IS".

[i.6] M. S. Borella et al.: "Methods for determining sendable information content based on a determined network latency", US Patent 6,182,125, Jan. 2001.

[i.7] IETF RFC 7490: "Remote Loop-Free Alternate (LFA) Fast Reroute (FRR)".

[i.8] A. Colvin: "CSMA with collision avoidance" in: Computer Communications 6.5 (1983), pp. 227-235.

[i.9] IEC 62439-3:2009: "Industrial communication networks - High availability automation networks - Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)".

[i.10] IEC 62591:2016: "Industrial networks - Wireless communication network and communication profiles - WirelessHART™".

[i.11] IEC 62734:2014: "Industrial networks - Wireless communication network and communication profiles - ISA 100.11a".

[i.12] IEC 62601:2015: "Industrial networks - Wireless communication network and communication profiles - WIA-PA".