IETF Contribution Through Collaborative Research Project On IIOT

By

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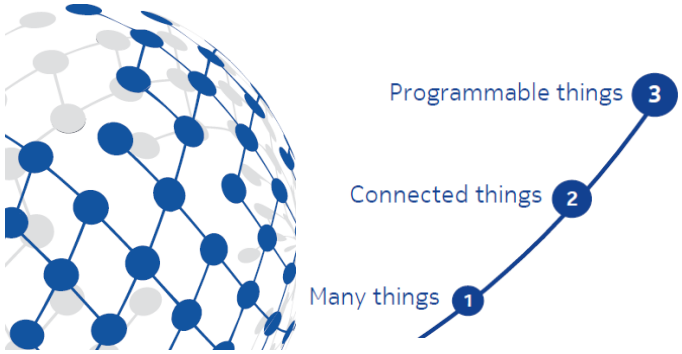
Government of India

Outline

- Introduction
- IoT and IIoT
- IoT Protocols and Standards
- IETF
- 6LoWPAN and 6TiSCH
- IETF Participation
  - Participation in IETF Draft proposals
  - New IETF Draft proposals
  - Participation in IETF meetings
  - 6TiSCH Testbed Activities
  - National Workshops
- Contribute to IETF
- Conclusion

Introduction

- **While the past has been about connecting people, the future is about connecting things – improving personal life & optimizing business process**



MUI, a smart wooden plank , an Internet connected plank of wood

- **Touch sensitive interface**
- **Built in microphone**
- **Google Assistant**

Showcased recently by a Japanese company at CES,2019 at Las Vegas

- **Global AI market is expected to grow by 36.6 % annually to US $190.61 billion by 2025**
- **Gartner forecasts 20.8 billion connected devices by 2020, business to grow by US$ 520 billion in 2021**

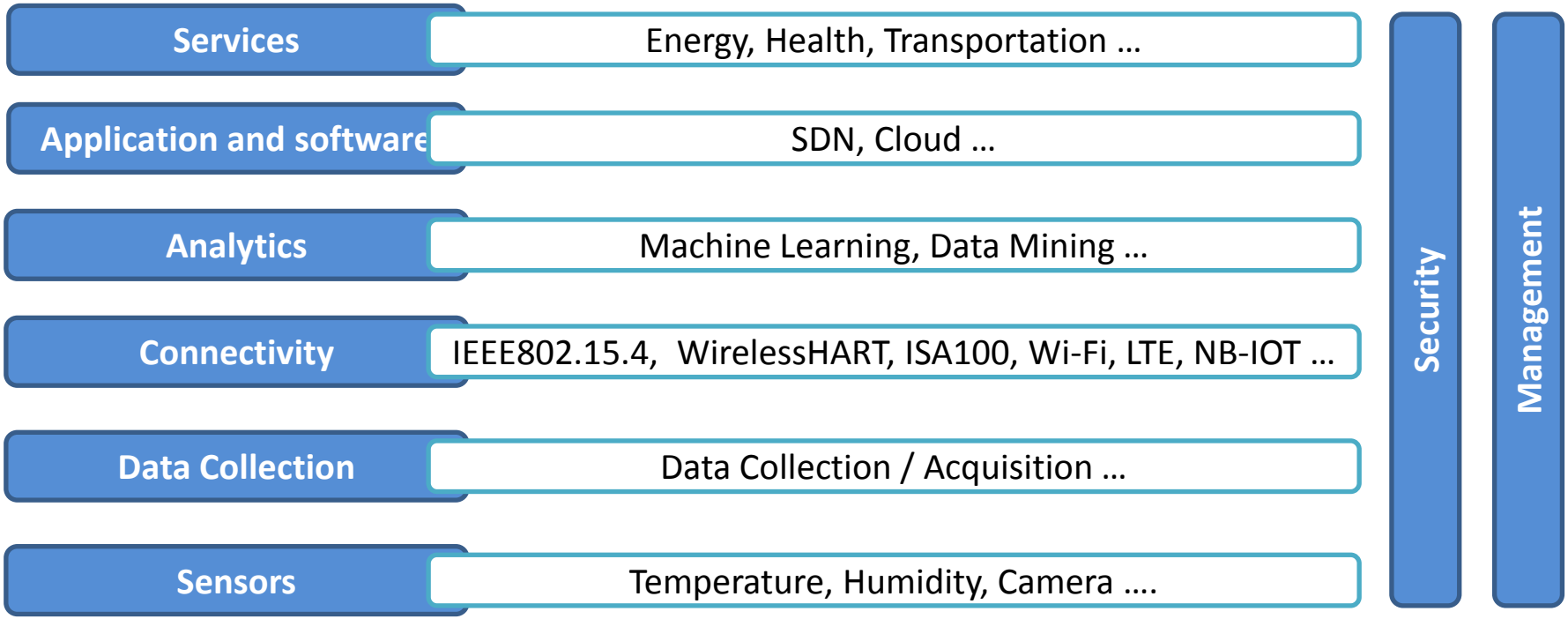
Internet of Things

- The Internet of Things is the network of physical objects or things" embedded with electronics, software, sensors, and connectivity to enable objects to exchange data with the manufacturer, operator and/or other connected devices.

  - a definition from IETF

- Creating new growth opportunities for business
  - Improve employee efficiency
  - Deliver better customer experiences
  - Track supply chain, assets and operations

IoT Ecosystem

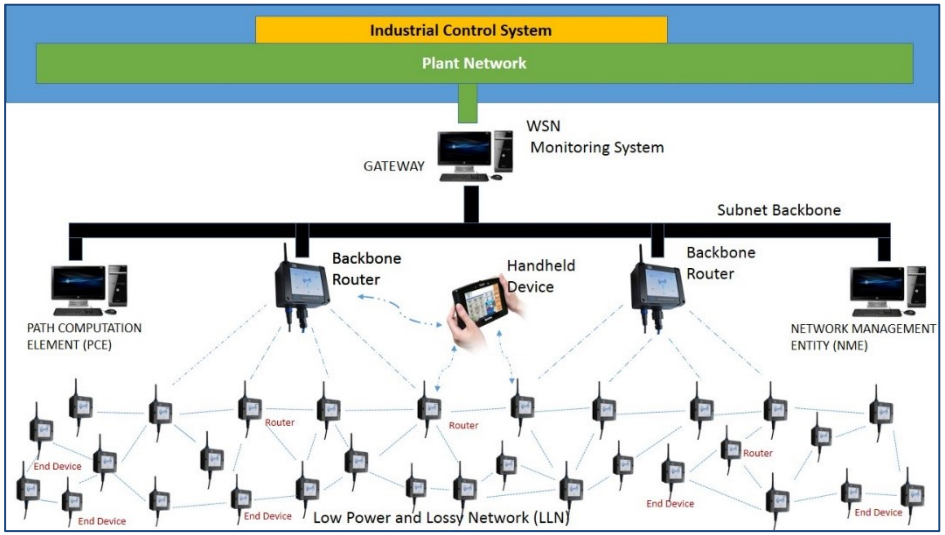


IoT Business Challenges

- Implementation and faster adoption (including hardware)
- Lack of standardisation
- Regulation for ethical issues
- Interoperability
- Security
- Connectivity

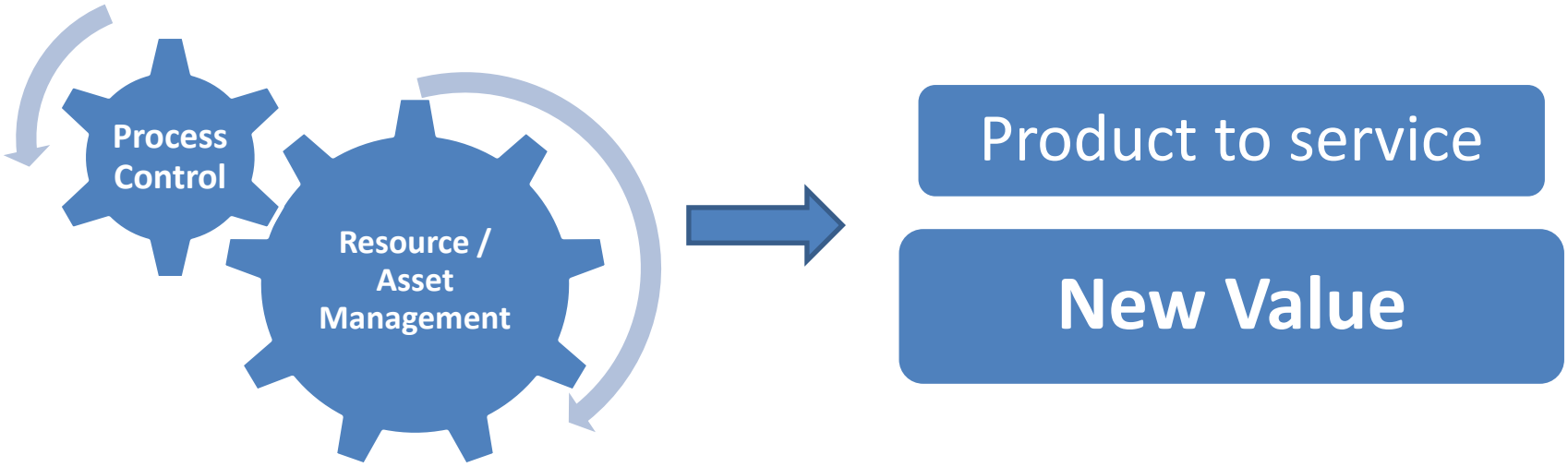
Industrial IoT (IIoT)

- IoT networks connect people processes and applications so that business can quickly adapt to changing conditions
- Smart machines are good at accurately and consistently capturing and communicating data
- Has significant potential to improve automation, industrial control, supply chain traceability, overall efficiency and asset performance



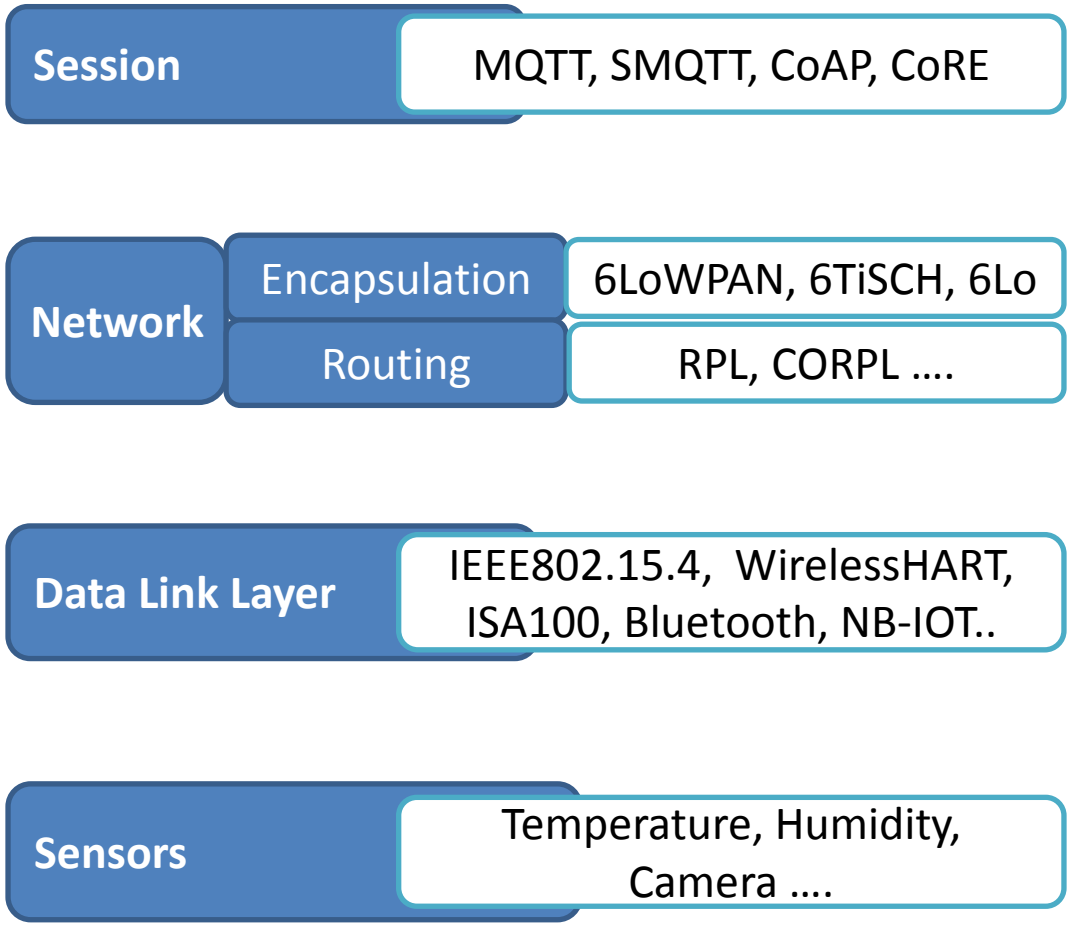
IIoT Requirements

- ❑ Low latency and ultra reliability
- ❑ Resilience in case of failures
- ❑ Flexible and scalable deployment model
- ❑ Supports multiple communication technologies



IoT Protocols and Standards

- **Constrained devices requires optimized versions of Internet Protocols**
- **The IETF WG specifies key IoT standards and guidance, used by a variety of companies, as well as IoT standards organizations and alliances, to build and specify interoperable systems.**



IETF

- The Internet Engineering Task Force (IETF) is a global community of network designers, operators, vendors, and researchers that develops Internet protocols
- GOAL : To make the Internet work better

RFC 768	UDP - User Datagram Protocol	[1980]
RFC 791	IPv4 – Internet Protocol	[1981]
RFC 792	ICMPv4 – Internet Control Message Protocol	[1981]
RFC 793	TCP – Transmission Control Protocol	[1981]
RFC 862	Echo Protocol	[1983]
RFC 1101	DNS Encoding of Network Names and Other Types	[1989]
RFC 1191	IPv4 Path MTU Discovery	[1990]
RFC 1981	IPv6 Path MTU Discovery	[1996]
RFC 2131	DHCPv4 - Dynamic Host Configuration Protocol	[1997]
RFC 2375	IPv6 Multicast Address Assignments	[1998]
RFC 2460	IPv6	[1998]
RFC 2463	ICMPv6 - Internet Control Message Protocol for IPv6	[1998]
RFC 2765	Stateless IP/ICMP Translation Algorithm (SIIT)	[2000]
RFC 3068	An Anycast Prefix for 6to4 Relay Routers	[2001]
RFC 3307	Allocation Guidelines for IPv6 Multicast Addresses	[2002]
RFC 3315	DHCPv6 - Dynamic Host Configuration Protocol for IPv6	[2003]
RFC 3484	Default Address Selection for IPv6	[2003]
RFC 3587	IPv6 Global Unicast Address Format	[2003]
RFC 3819	Advice for Internet Subnetwork Designers	[2004]
RFC 4007	IPv6 Scoped Address Architecture	[2005]
RFC 4193	Unique Local IPv6 Unicast Addresses	[2005]
RFC 4291	IPv6 Addressing Architecture	[2006]

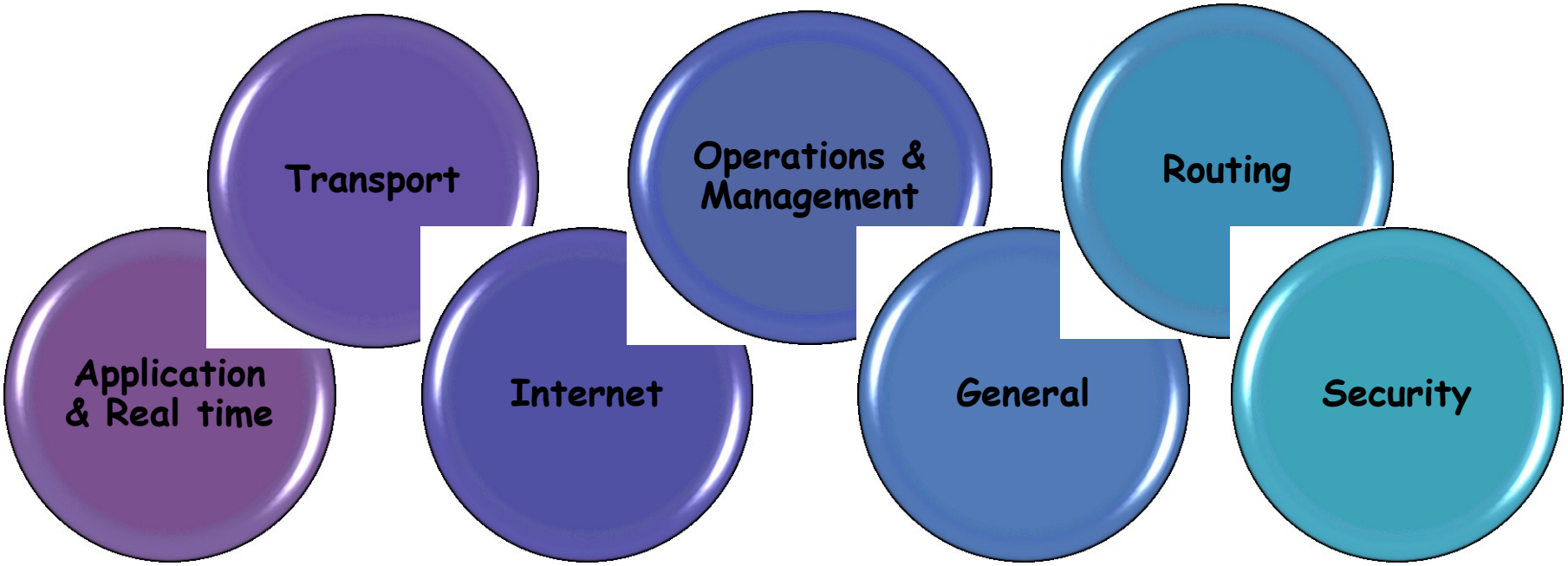
IETF WG

- Technical work of the IETF is carried out in Working Groups (WGs)
  - WGs are the primary mechanism for the development of IETF specifications and guidelines, many of which are intended to be standards or recommendations
  - Work Groups(WGs) will be chartered with one or more deliverables

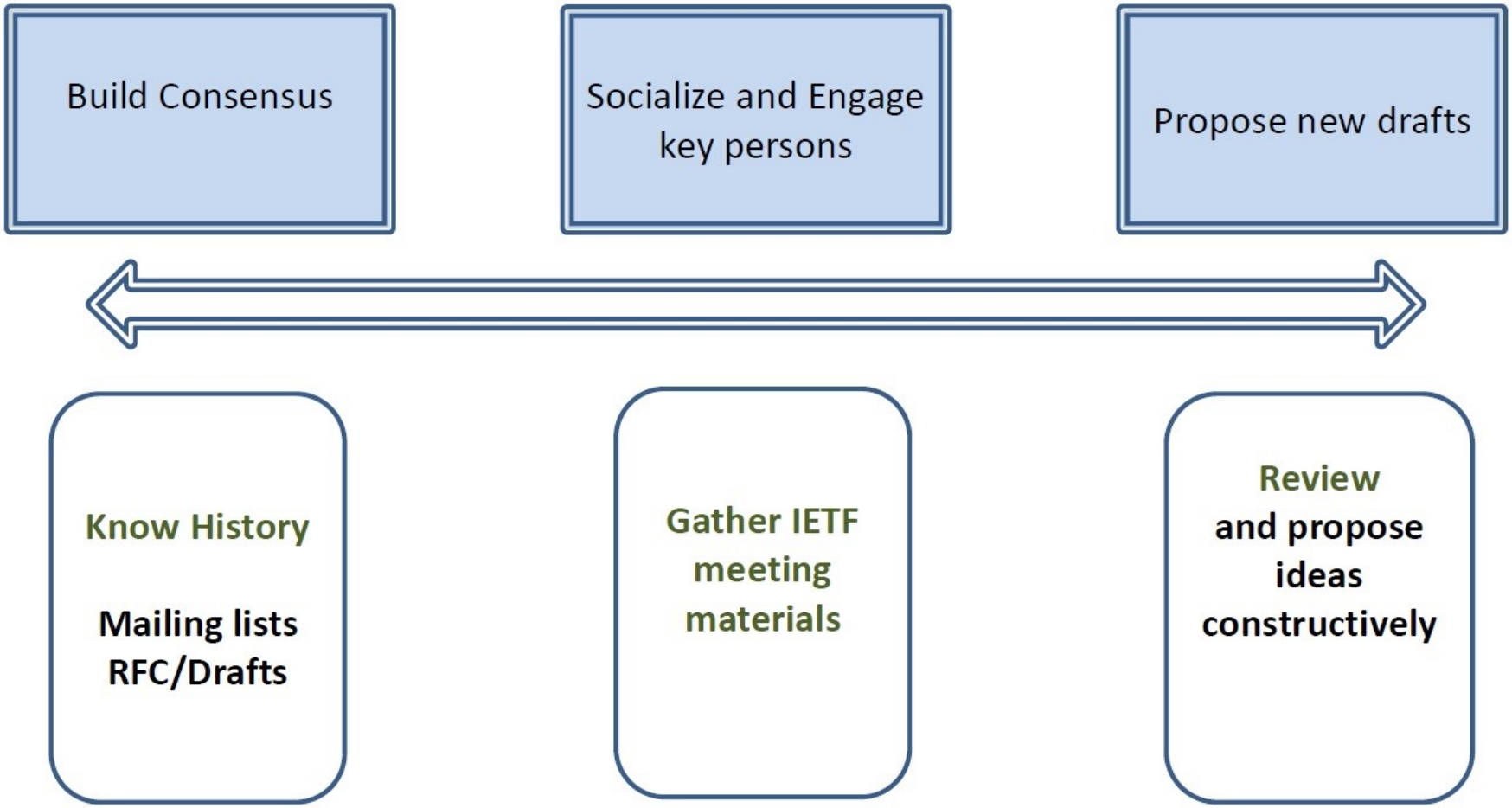
- 6LoWPAN - IPv6 over Low-power WPAN ; First IETF IoT WG
- ROLL - Routing Over Low-power and Lossy networks
- CoRE - Constrained RESTful Environments

- Most of the work happens online over WG mailing lists
- In-person interactions take place during IETF meetings
- Virtual meetings can happen often

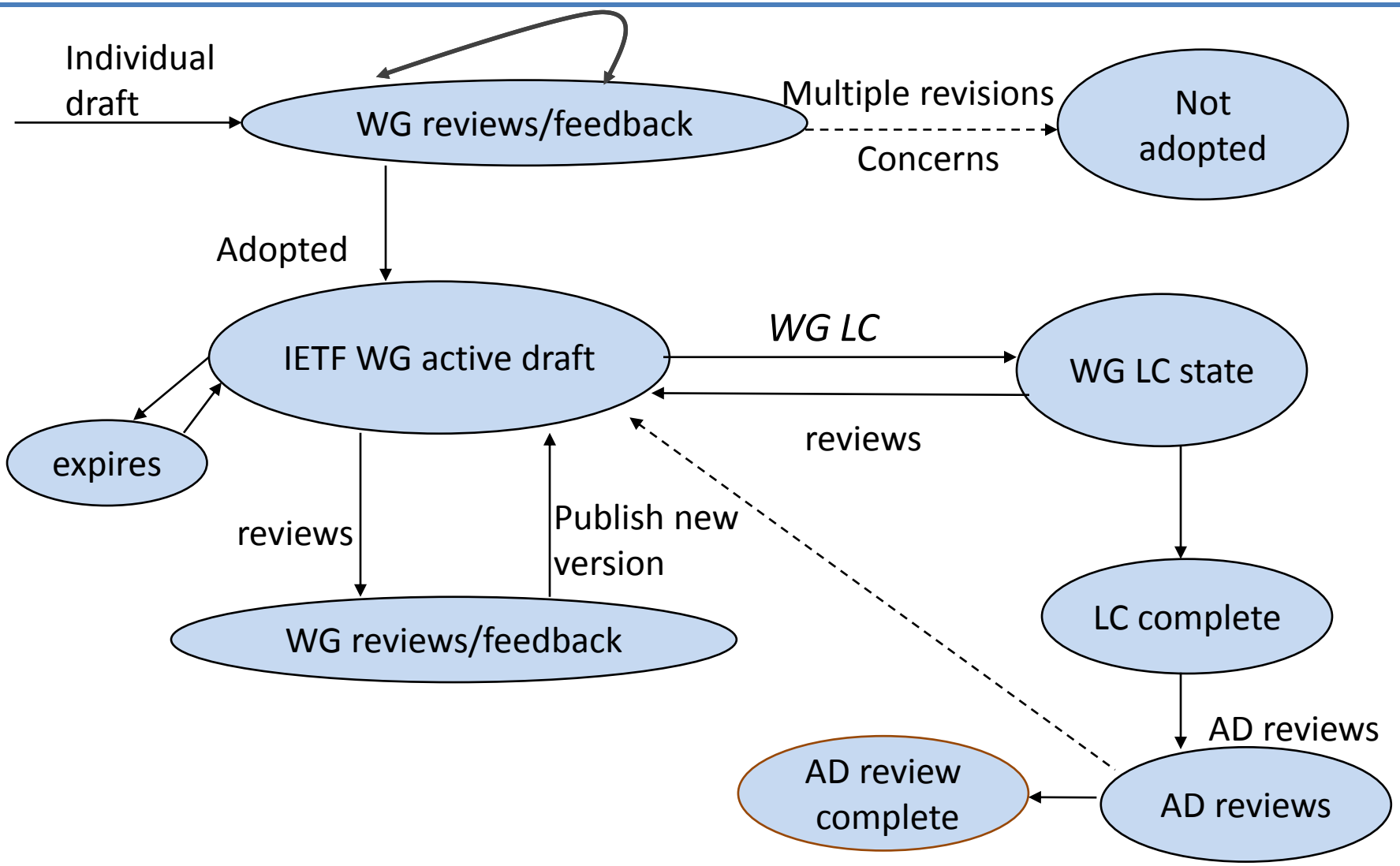
IETF Working Areas



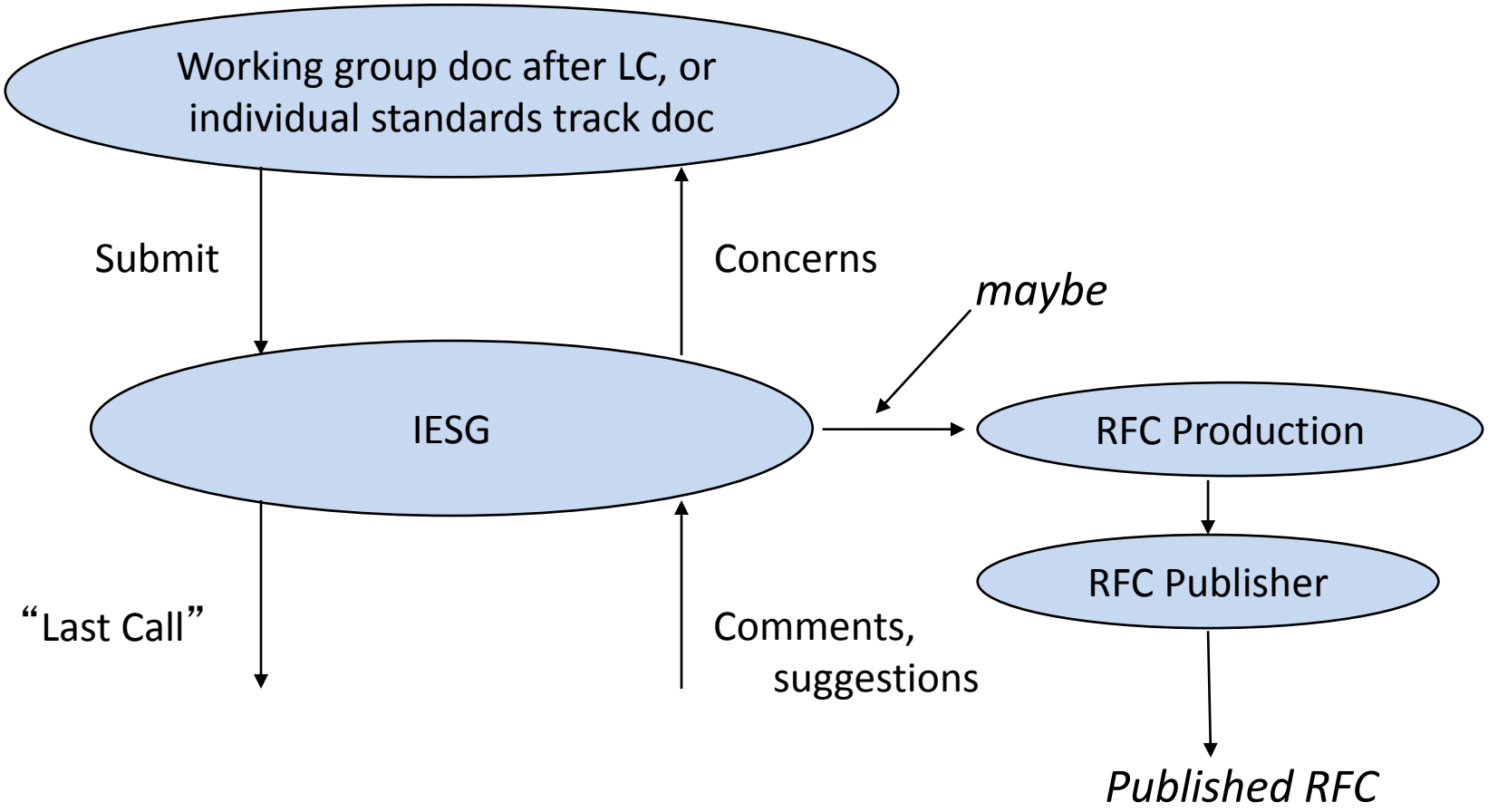
IETF Culture and Proceedings



Life Cycle of a draft in WG



Life Cycle of a draft after LC



IETF 6LoWPAN WG

❑ IPv6 over Low power WPAN (6LoWPAN)

- **Methods for adapting IPv6 to IEEE 802.15.4 (WPAN) networks**
- **IPv6 header compression and optimizations for neighbour discovery.**
- **Fragmentation, reassembly and routing**

❑ RFC4919

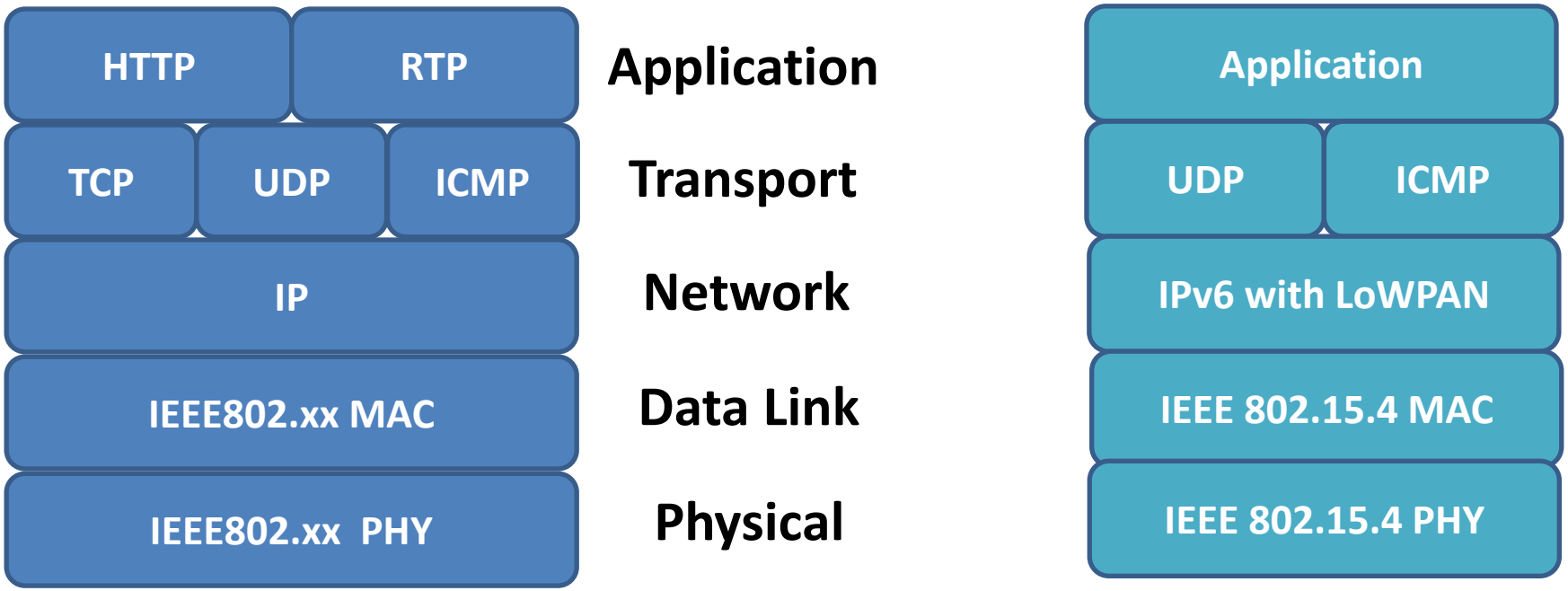
"IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs):Overview, Assumptions, Problem Statement, and Goals"

❑ RFC4944

"Transmission of IPv6 Packets over IEEE 802.15.4 Networks"

6LoWPAN Stack

Interoperable implementations and constructs for building 6LoWPAN networks !!

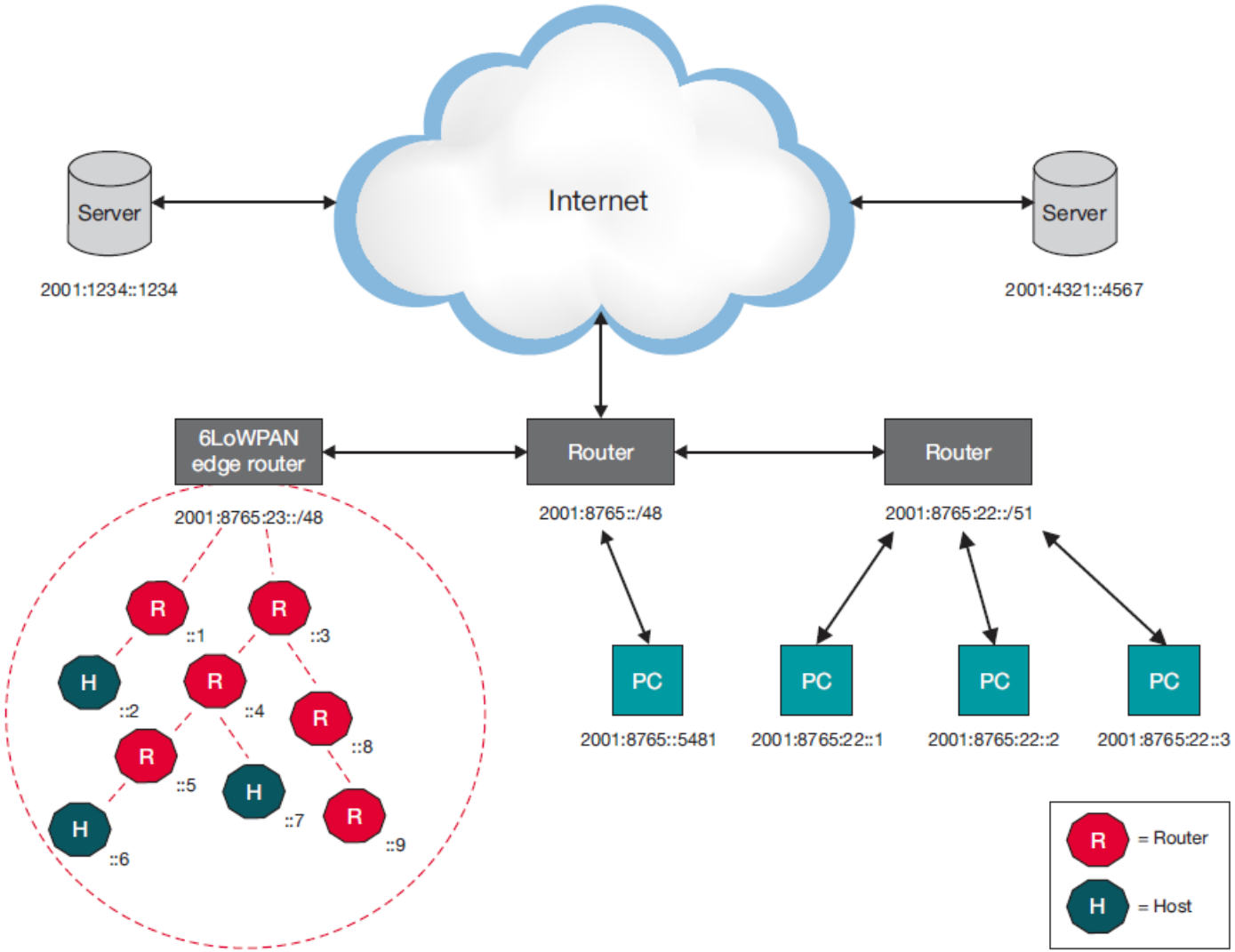


Simplified OSI Model

6LoWPAN Stack

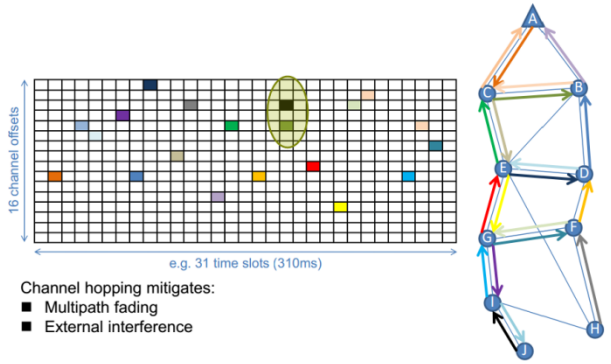
- Supports IEEE802.15.4 networks
- Being adapted to Sub- 1 GHz low power RF, Bluetooth & Power Line Control

6LoWPAN Architecture



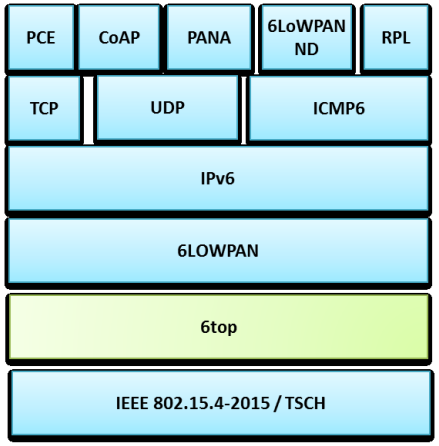
IETF 6TiSCH WG

❑ IPv6 over the TSCH mode of the IEEE 802.15.4-2015 standard (6TiSCH)

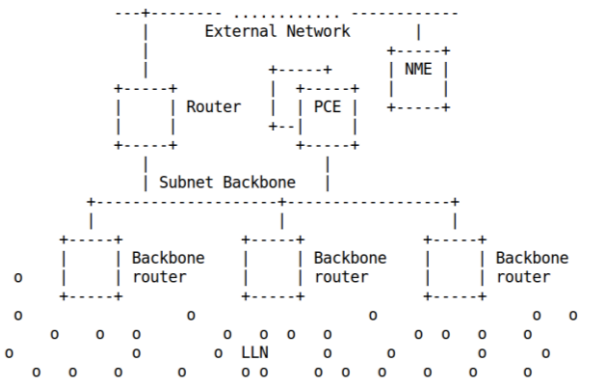


❑ Current Charter Highlights

- Propose Minimalistic Operation to setup a IPv6 network over 6TiSCH network
- Distributed routing over a static schedule using RPL
- Dynamic allocation of cells between peer nodes
- Joining Securely
- Creating Deterministic Tracks
- 6TiSCH Architecture
- 6top Sublayer
- 6top Scheduling Function



6TiSCH protocol stack



6TiSCH Network

WIPSeN Project

- **Wireless Internet Protocol enabled Time slotted and Channel hopping Sensor Network (WIPSeN)**
- **Aim**
  - Active participation in the IETF draft proposals
  - Participation in the IETF discussion groups
  - 6TiSCH testbed for evaluating the proposed architecture and IETF drafts and provide valuable feedback to IETF community
  - Propose new IETF draft proposals
  - Conduct National Workshops to create awareness
- **Funding Agency**
  - **Ministry of Electronics and Information Technology (MeitY) , Government of India**

IETF WG's of Interest

6TiSCH	IPv6 over the TSCH mode of IEEE 802.15.4e
ROLL	Routing Over Low power and Lossy networks
DetNet	Deterministic Networking
6Lo	IPv6 over Networks of Resource-constrained Nodes

Active Participation in the IETF draft proposals

❑ WG mailing list discussions

Actively participated in the 6tisch, roll, detnet and 6lo WG mailing list discussions where we proposed valuable suggestions and provided feedback to the existing drafts.

- Transmit Power Control proposal in the 6top layer was well received. Invited to write proposal for IEEE 802.15.4

  http://www.ietf.org/mail-archive/web/6tisch/current/msg03969.html

- Participated in more than 8 IETF draft proposals and received positive response from authors and working group members

❑ WebEx meetings

Actively participated in bi-weekly WebEx meetings

https://bitbucket.org/6tisch/meetings/wiki/170623_webex

Participation in IETF Meetings

IETF 96 – IIREF Fellowship

- Team members attended the IETF96 meeting held at **Berlin, Germany**

IETF 97 – Remote participation

- All the 3 drafts co-authored by us were presented during this meeting
- AODV-RPL draft has been adopted by ROLL WG

IETF 98 – IIREF Fellowship

- A team member attended the IETF98 meeting held at **Chicago, USA**

IETF 99 – Remote participation

- Remotely presented the draft and OpenWSN work to 6TiSCH WG

IETF 100 – ISOC Fellowship

- A team member attended IETF100 meeting held at **Singapore**

IETF 103 – ISOC Fellowship

- Team members attended IETF 103 meeting held at **Thailand**

New IETF Drafts

3 IETF drafts proposed

- **Packet Delivery Deadline time in 6LoWPAN Routing Header**

  WG : IPv6 over Networks of Resource-constrained Nodes (6lo)
  Area : Internet Area (int)

- **Asymmetric AODV-P2P-RPL in Low-Power and Lossy Networks (LLNs)**

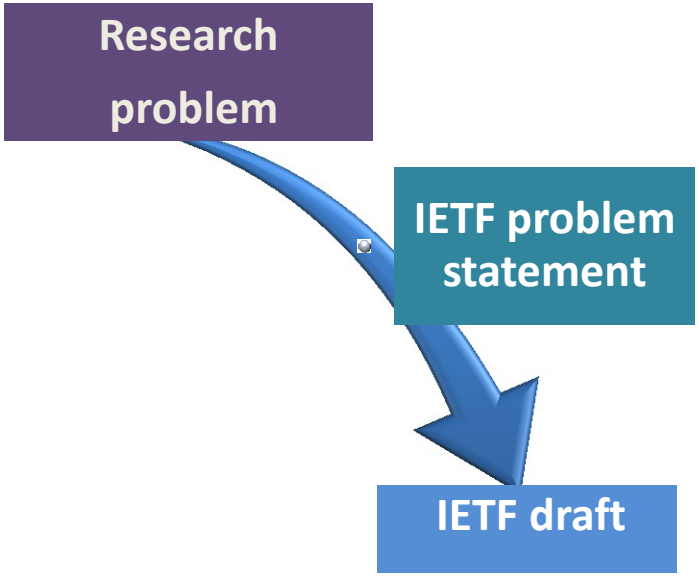
  WG : Routing Over Low power and Lossy networks (roll)
  Area : Routing Area (rtg)

- **Scheduling Function One(SF1) for hop-by-hop Scheduling in 6tisch Networks**

  WG : IPv6 over the TSCH mode of IEEE 802.15.4e (6tisch)
  Area : Internet Area (int)

Research in IIoT leading to an IETF draft

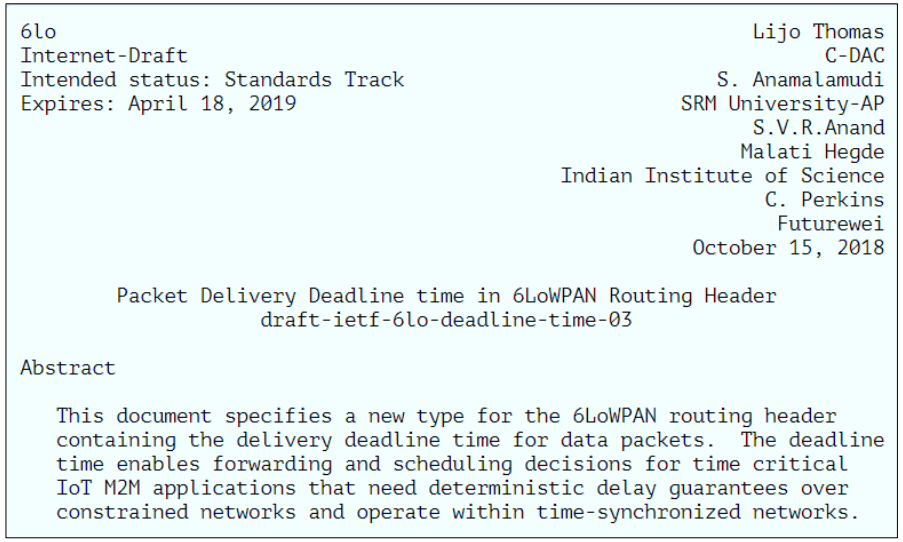
- Research being carried out in IISc for developing algorithms for time critical application traffic
- Algorithms assume packets carrying deadline information
- Encouragement from WG members including Pascal Thubert, Thomas Watteyne, Shwetha Bhandari and others
- Proposed deadline time as part of 6Lo header over mailing list



IETF draft 1

Packet Delivery Deadline time in 6LoWPAN Routing Header

- Draft proposed in 6Lo Working Group
- Link : https://datatracker.ietf.org/doc/draft-ietf-6lo-deadline-time/
- Draft revisions were presented in IETF97, IETF98, IETF99 meetings
- Implemented the draft in OpenWSN which has been integrated with the OpenWSN main distribution and is available for free download



6lo
Internet-Draft
Intended status: Standards Track
Expires: April 18, 2019

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C-DAC
S. Anamalamudi
SRM University-AP
S.V.R.Anand
Malati Hegde
Indian Institute of Science
C. Perkins
Futurewei
October 15, 2018

Packet Delivery Deadline time in 6LoWPAN Routing Header
draft-ietf-6lo-deadline-time-03

Abstract

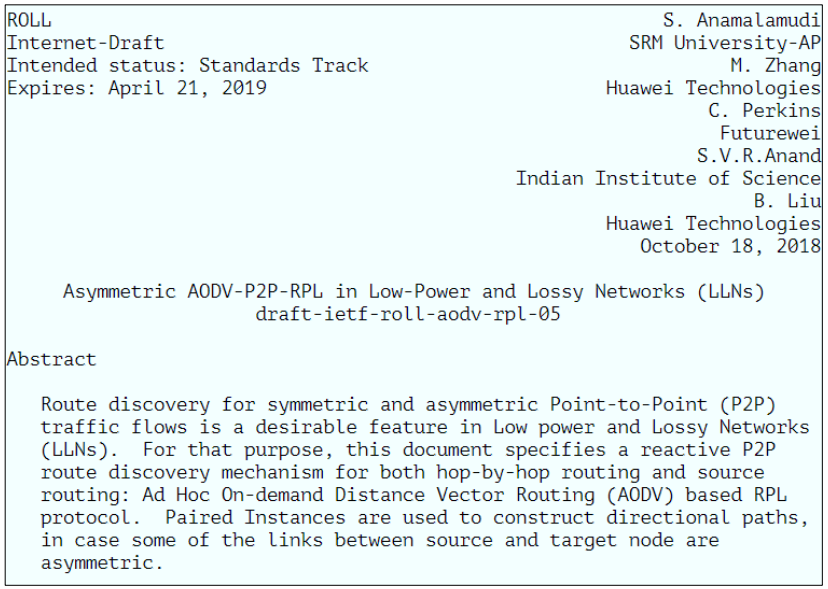
This document specifies a new type for the 6LoWPAN routing header containing the delivery deadline time for data packets. The deadline time enables forwarding and scheduling decisions for time critical IoT M2M applications that need deterministic delay guarantees over constrained networks and operate within time-synchronized networks.

Adopted by WG → Completed AD review → Under IESG review

IETF draft 2

Asymmetric AODV-P2P-RPL in Low-Power and Lossy Networks (LLNs)

- **Draft proposed in ROLL Working Group**
- **Link : https://datatracker.ietf.org/doc/draft-ietf-roll-aodv-rpl/**
- **Draft revisions presented in IETF 96,97,98,99 meetings**
- **Implemented the draft in Contiki OS**



ROLL
Internet-Draft
Intended status: Standards Track
Expires: April 21, 2019

S. Anamalamudi
SRM University-AP
M. Zhang
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Indian Institute of Science
B. Liu
Huawei Technologies
October 18, 2018

Asymmetric AODV-P2P-RPL in Low-Power and Lossy Networks (LLNs)
draft-ietf-roll-aodv-rpl-05

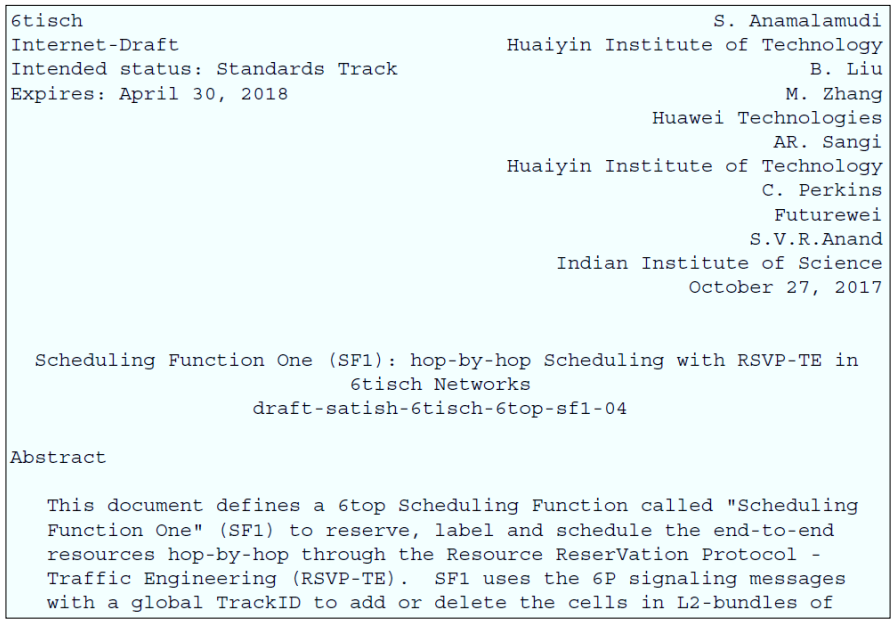
Abstract

Route discovery for symmetric and asymmetric Point-to-Point (P2P) traffic flows is a desirable feature in Low power and Lossy Networks (LLNs). For that purpose, this document specifies a reactive P2P route discovery mechanism for both hop-by-hop routing and source routing: Ad Hoc On-demand Distance Vector Routing (AODV) based RPL protocol. Paired Instances are used to construct directional paths, in case some of the links between source and target node are asymmetric.

IETF draft 3

Scheduling Function One (SF1) for hop-by-hop Scheduling in 6tisch Networks

- **Draft proposed in 6TiSCH Working Group**
- **Link : https://datatracker.ietf.org/doc/draft-satish-6tisch-6top-sf1/**
- **Draft reviewed in IETF 96, 97 meetings**



6tisch
Internet-Draft
Intended status: Standards Track
Expires: April 30, 2018

S. Anamalamudi
Huaiyin Institute of Technology
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M. Zhang
Huawei Technologies
AR. Sangi
Huaiyin Institute of Technology
C. Perkins
Futurewei
S.V.R.Anand
Indian Institute of Science
October 27, 2017

Scheduling Function One (SF1): hop-by-hop Scheduling with RSVP-TE in 6tisch Networks
draft-satish-6tisch-6top-sf1-04

Abstract

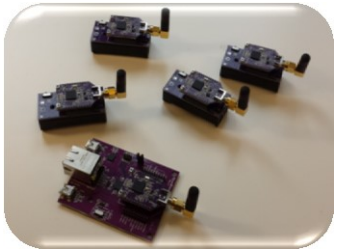
This document defines a 6top Scheduling Function called "Scheduling Function One" (SF1) to reserve, label and schedule the end-to-end resources hop-by-hop through the Resource ReserVation Protocol - Traffic Engineering (RSVP-TE). SF1 uses the 6P signaling messages with a global TrackID to add or delete the cells in L2-bundles of

Individual Draft

6TiSCH Testbed Activities

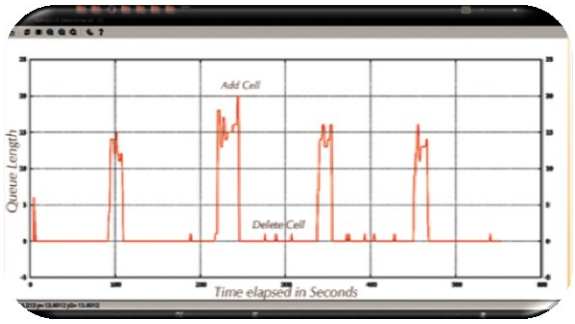
Hardware

- OpenMote
- WiSMote
- Telosb



Software

- ContikiOS
- OpenWSN



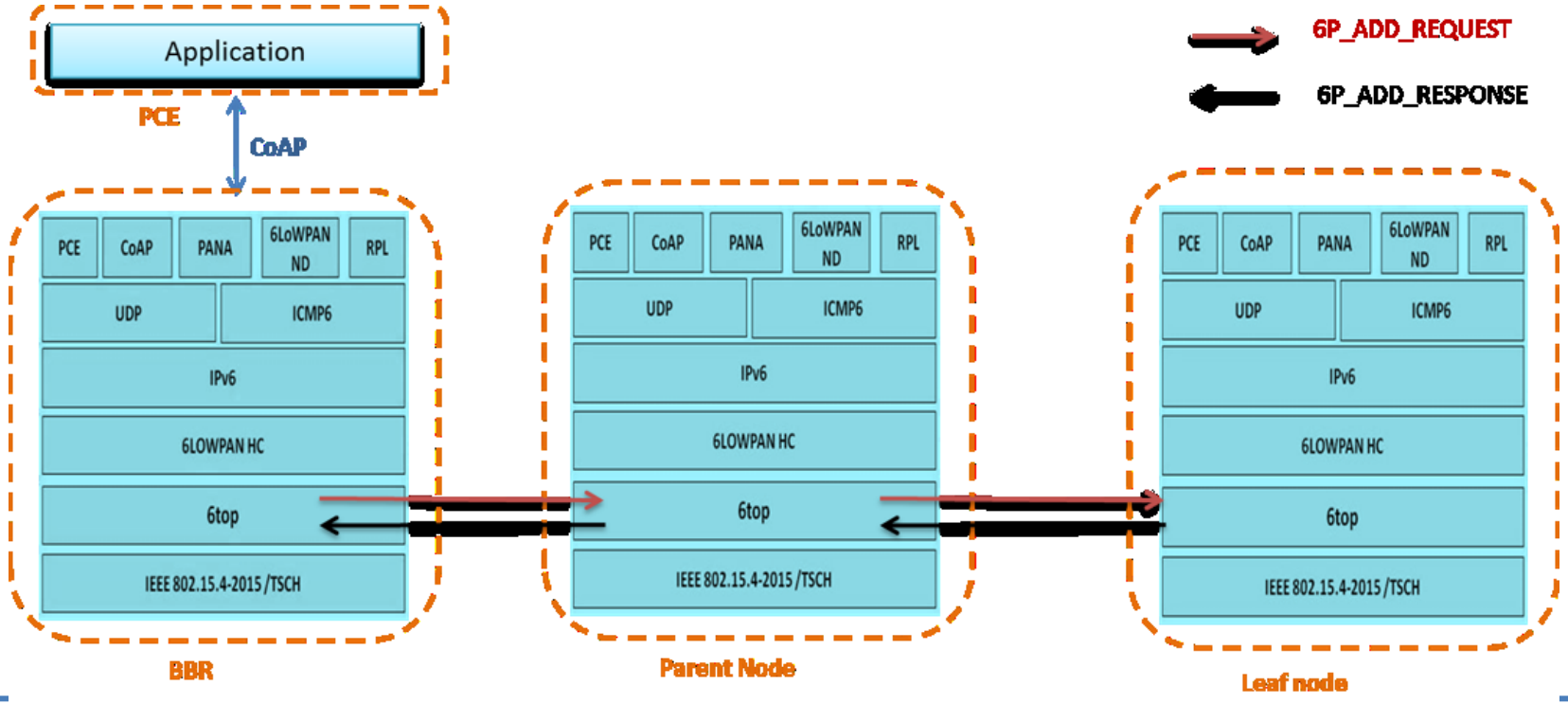
Simulation Environment

- Cooja
- Python Simulator

6TiSCH : Implementation of 6top layer

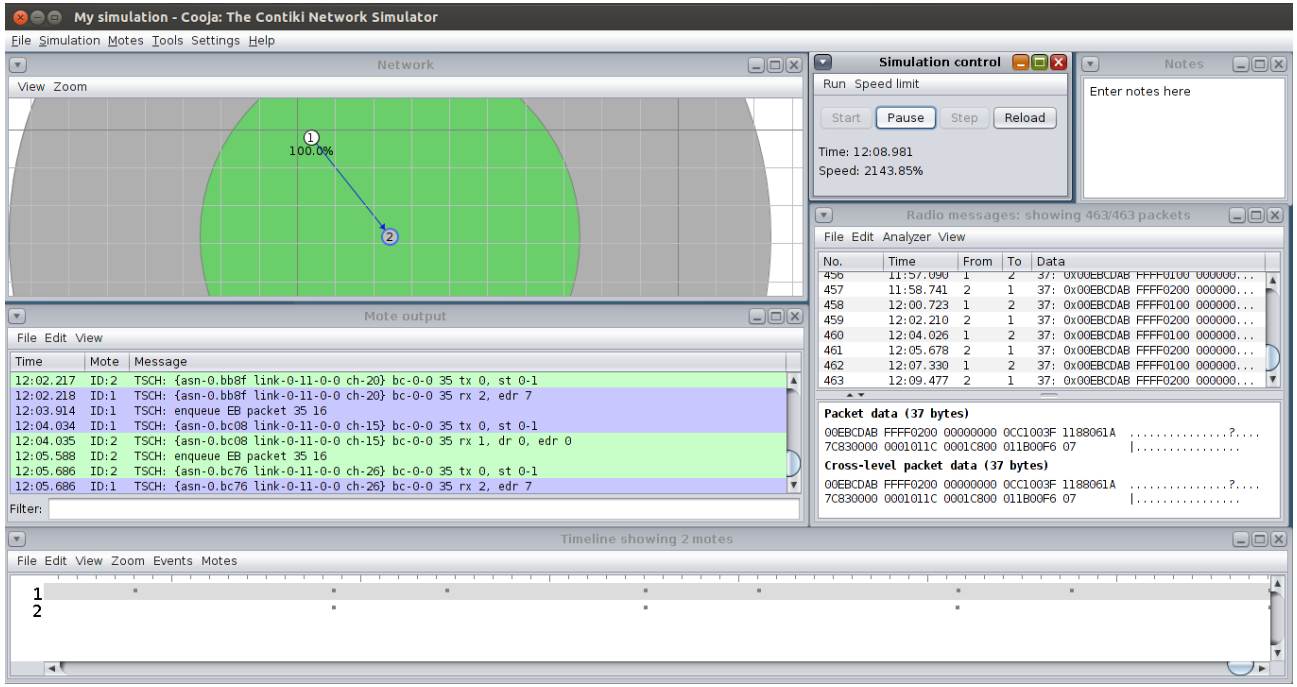
❑ 6top layer implementation on Contiki OS

- Designed and implemented the 6top layer on Contiki OS and validated the same using OpenMote Hardware and Cooja simulator
- Contributed the 6top layer code to Contiki OS



ROLL : Implementation of AODV-RPL

- Implementation of AODV-RPL on Contiki OS
- For supporting delay sensitive IoT applications, a basic debt-based scheduling algorithm was designed and implemented on 6TiSCH simulator



6tisch network simulation on Cooja simulator (Contiki OS)

Testbed setup @ CDAC

6Lo: Implementation of Deadline Draft

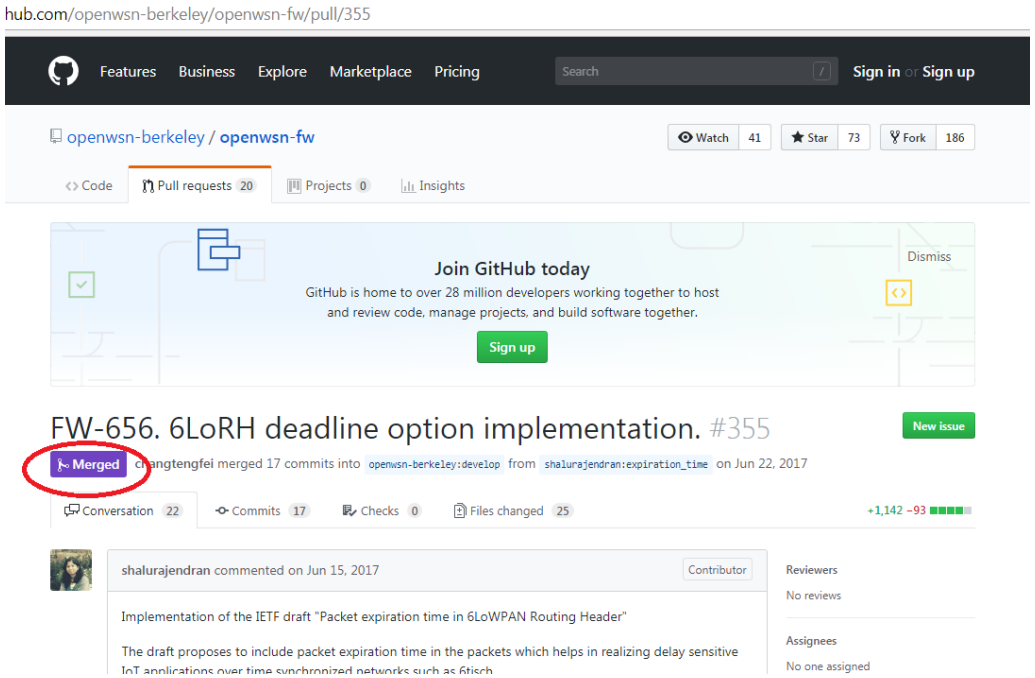
❑ 6Lo packet expiration draft implementation on OpenWSN

- **Implemented our 6lo draft "draft-lijo-6lo-expiration-time-04" in OpenWSN**

  https://github.com/openwsn-berkeley/openwsn-fw/pull/355
  https://github.com/openwsn-berkeley/openwsn-sw/pull/150

- **Contributed to the OpenWSN open source distribution**
- **Implemented Earliest Deadline First scheduling algorithm**

Submitted to GitHub → **Merged to main stack**

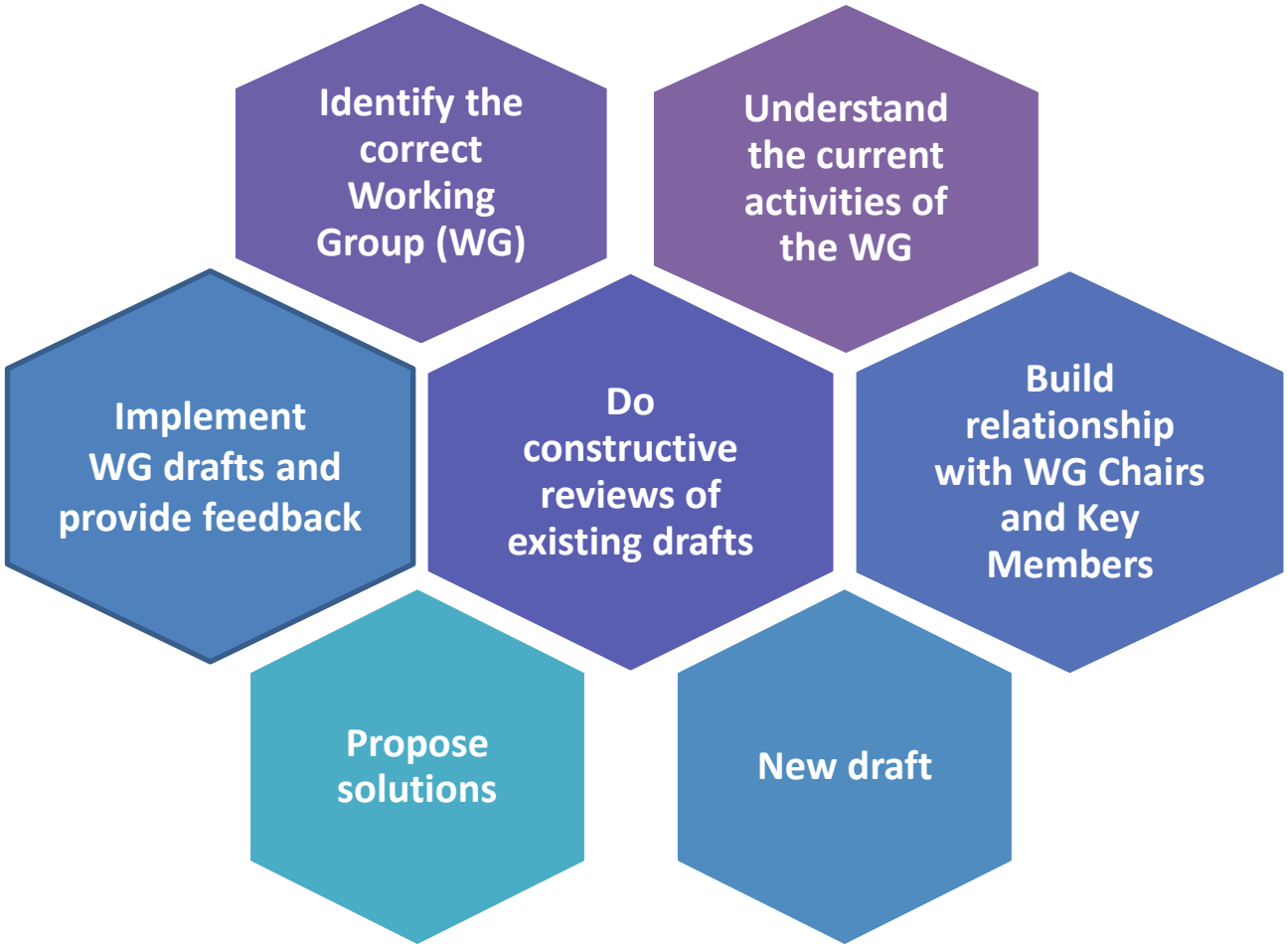


Workshops

- "**IETF Participation and Emerging Industrial Networking Technologies**" was held at IISc, Bangalore.

- "**Realising Anything as a Service in IoT : Technologies and Standards**", was held at C-DAC, Thiruvananthapuram.

Contribute to IETF ?



IETF Fellowships

IIREF

Indian Internet Research and Engineering Forum
https://iiref.in/fellowship

ISOC

Internet Society Fellowship
https://www.internetsociety.org/

Conclusion

- Participation in standardization process
- Improve Indian participation in IETF
- With the release of new Standards
- Indian Companies to release new products & solutions quickly
- India to be a global player in world business

Acknowledgement

With gratitude, acknowledge the efforts of
T Santhosh, Malati Hegde, Jerry Daniel J
&
Senju Thomas Panicker, Satish Anamalamudi, Seema Kumar, Avinash Mohan, Anitha Varghese, Lavanya HM

Ministry of Electronics & Information Technology (MeitY), Government of India

Thank You

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Implementation of draft-ietf-6lo-deadline-time on a 6TiSCH Network

Demonstration Session

Centre for Development of Advanced Computing (C-DAC), Thiruvananthapuram
A Scientific Society of Ministry of Communications and Information Technology
Government of India

OpenWSN

- A project created at **University of California Berkeley** and extended at **INRIA** and at **Open University of Catalonia**
- Aims at providing **open-source implementations** of a complete protocol stack based on **Internet of Things** standards
- OpenWSN can be run in
  - **Simulation mode**
  - **Real hardware modules**

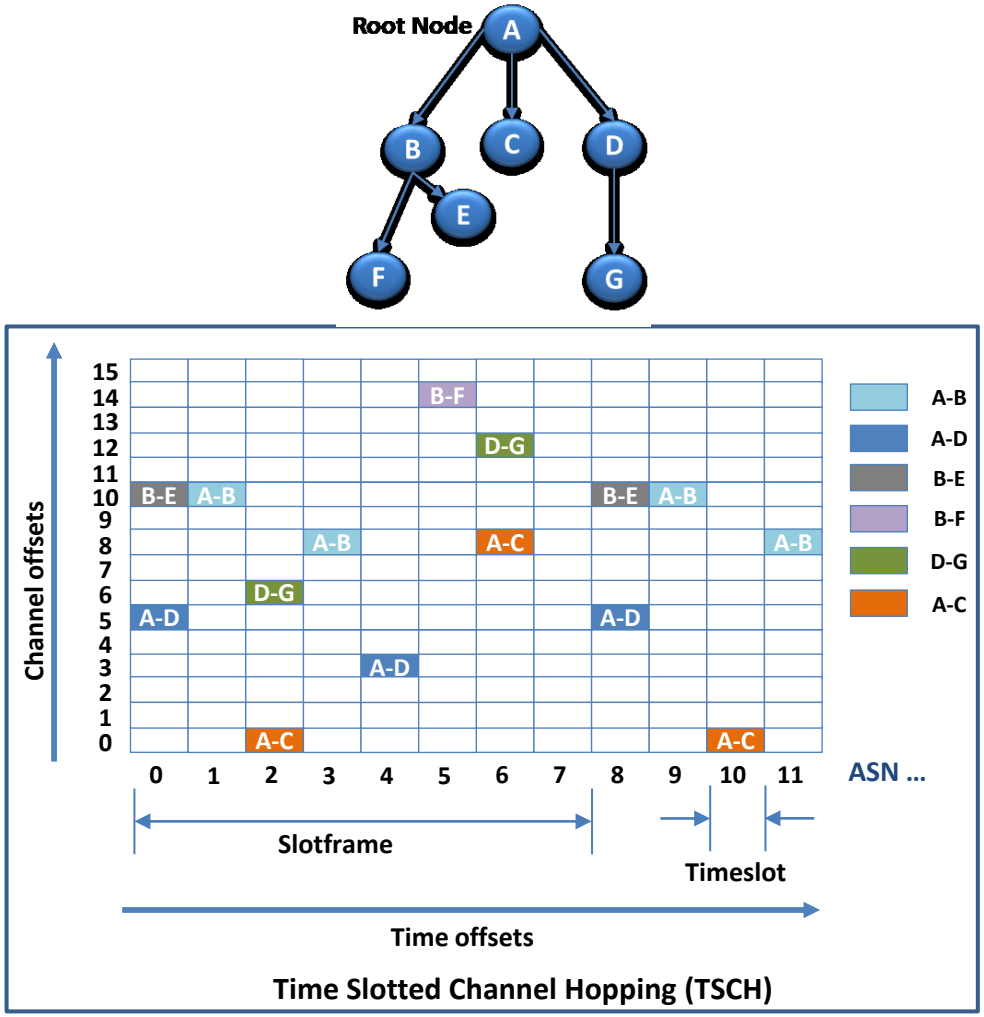
https://openwsn.atlassian.net/wiki/spaces/OW/overview

Demo

1. Multi-hop 6tisch network demonstration using OpenMote hardware

2. Implementation of draft-ietf-6lo-deadline-time on a 6TiSCH Network

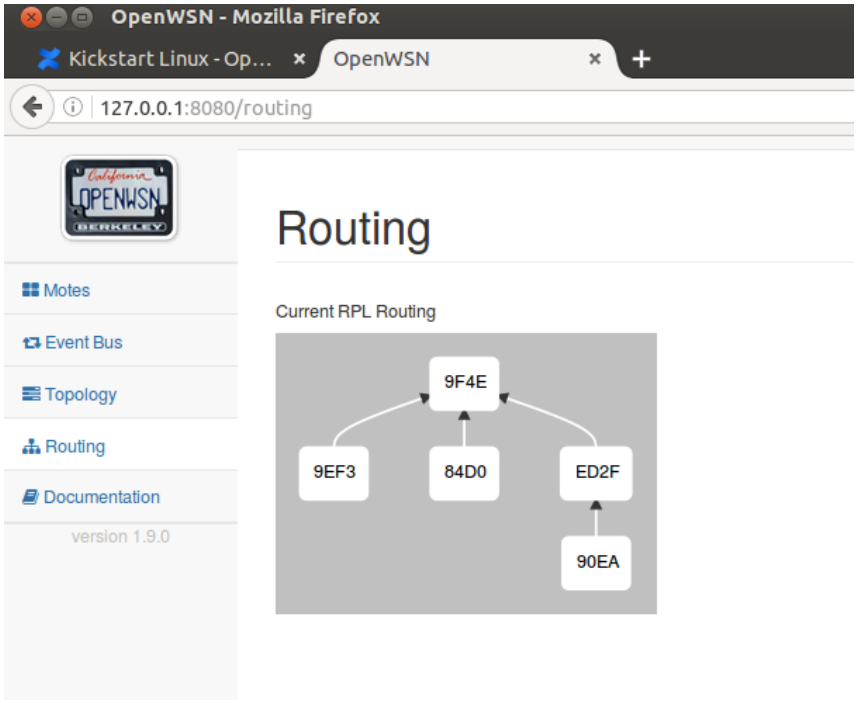
6TiSCH Minimal Network



- **Cell parametrs**
  - Slot_offset
  - Channel_offset
  - Link_option
- **Cell Types**
  - Hard cells
  - Soft cells
- **Slot duration : 10ms (ASN)**
- **Enhanced Beacons carrying Information Elements (IE)**
  - Sync IE
  - TSCH Timeslot IE
  - Channel Hopping IE
  - Frame & Link IE
- **RPL : Non Storing Mode**

OpenWSN Implementation on Real Hardware

6TiSCH Multi Hop Network Formation using OpenMote

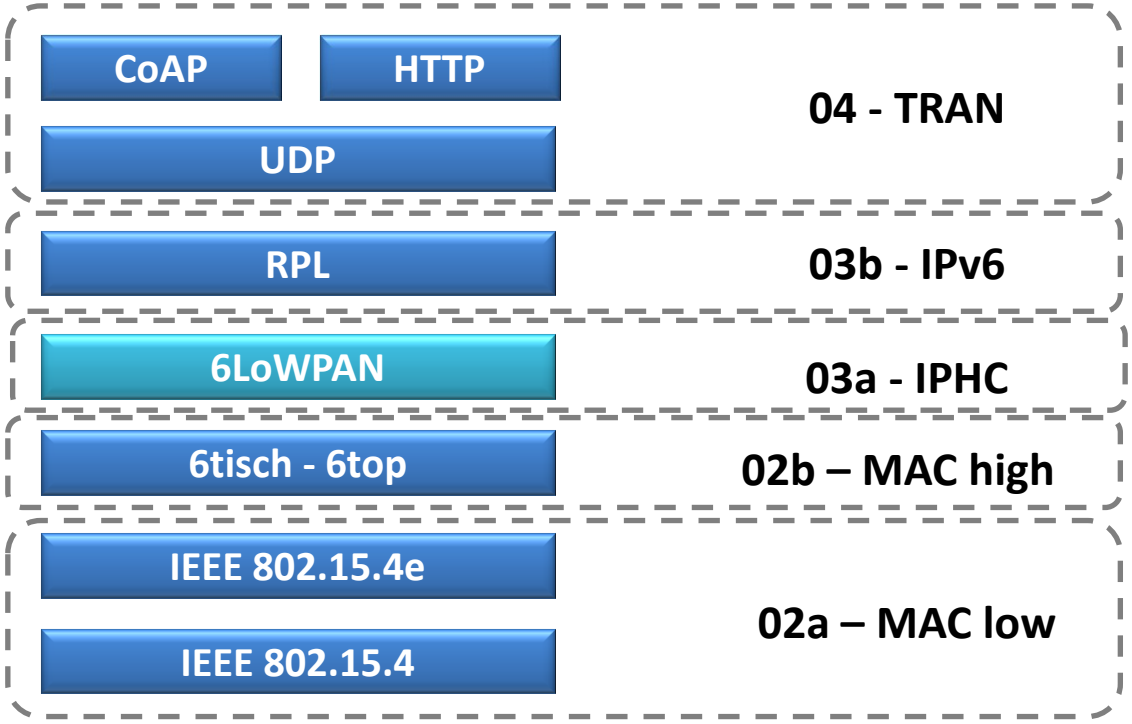


OpenMote-CC2538 **OpenBattery** **OpenBase**

Reference link : https://openwsn.atlassian.net/wiki/spaces/OW/pages/29196302/Kickstart+Linux

Deadline Draft Implementation

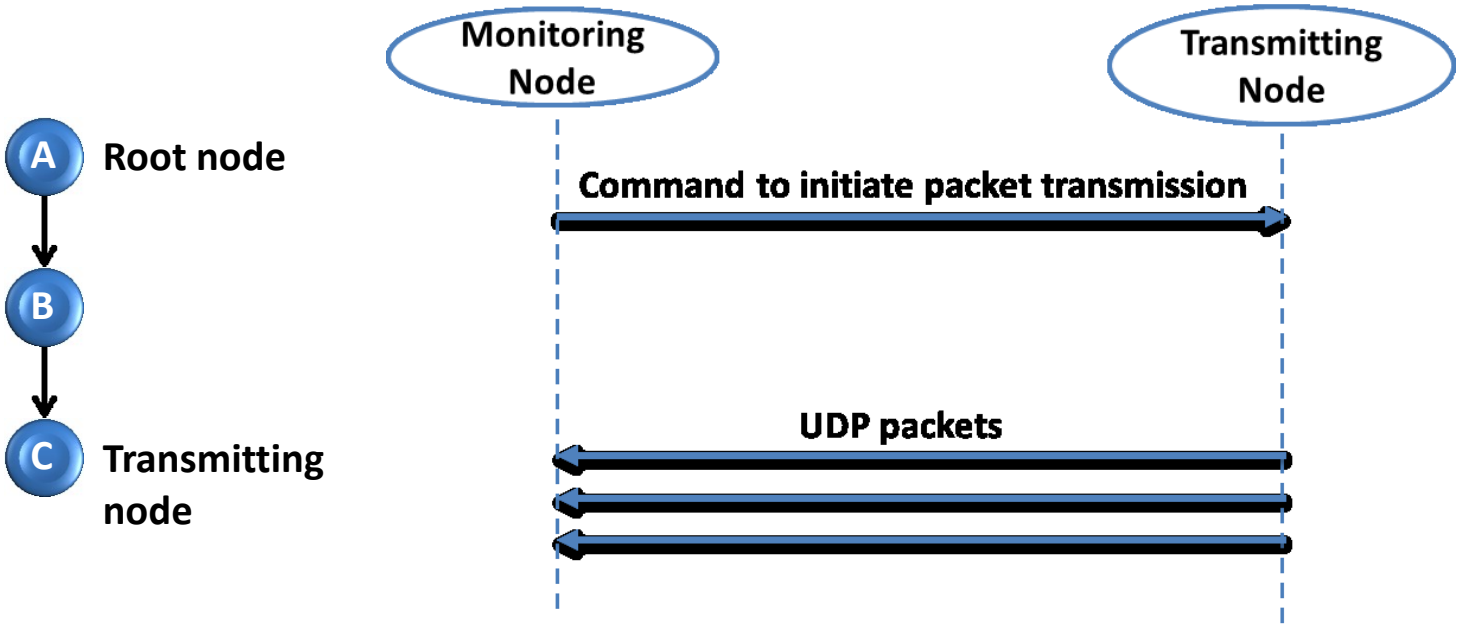
- The draft specifies expiration time of an IPv6 data packet



OpenWSN stack

OpenWSN Simulation

- Developed two UDP applications to monitor the network performance in meeting the packet deadline



Reference link : https://github.com/openwsn-berkeley/openwsn-fw/tree/develop/openapps/uexpiration

Thank you …

– Team WIPSeN