DetNet BoF
IETF #93

User’s View

Monday, July 20th, 2015

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Contents

- Wireless for industrial applications
- Professional audio
- Electrical utilities
- Building automation systems
- Radio/mobile access networks

Questions to be answered in every use case

- What is your application?
- How do you support the application today?
- What do you want to do differently in the future?
- What would you like the IETF to deliver?

Craig Gunther

IETF 93

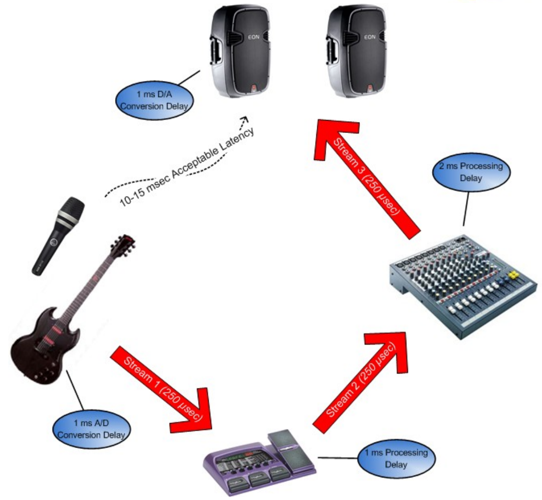
Prague, July 2015

Professional Audio Requirements

draft-gunther-detnet-proaudio-req

What is your application?

- Music and Film Production Studios
- Broadcast
- Cinema
- Live
  - 10-15 ms latency
  - Airports
  - Stadiums
  - Mega-churches
  - Theme parks



How do you support the application today?

- First obstacle was replacing huge amounts of analog wiring with digital networks
- Migration was accomplished with expensive proprietary hardware
  - Intensive manual configuration of entire A/V network
  - Over provisioned bandwidth requirements
  - Costly dual networks; one for Data and one for A/V
  - Large latency delays for buffering
  - Some networks physically protected from the IT department
- Separate AVB layer 2 network islands
  - Low latency = less buffering = $$$$$ savings
  - Time synchronized at all nodes
  - Dedicated interconnects between AVB islands

What do you want to do differently in the future?

- Share content between layer 2 AVB islands within a layer 3 intranet
  - 46 Tbps for 60,000 signals running across 1,100 miles of fiber
  - May even be geographically distributed with some acceptable buffering requirements (live + remote)
- As much plug-and-play as possible all the way up the protocol stack
  - Current solutions are manually configured and no one can “mess” with the network
  - Reduce requirement for specialized engineering
  - Allows quick on-the-fly setup
  - Allow re-use of unused reservation bandwidth for best-effort traffic

What would you like the IETF to deliver?

- Campus/Enterprise-wide (*think size of San Francisco*) layer 3 routing on top of AVB guaranteed networking where possible
  - Content delivery with lowest possible latency
  - Remove need to over provision networks
  - IntServ and DiffServ integration with AVB
- Single network wiring solution supporting Data and A/V to reduce infrastructure costs
- Multi-vendor interoperable solutions that are acceptable to the IT department (i.e. standards based)

Patrick Wetterwald

IETF 93
Prague, July 2015

Deterministic Networking Utilities requirements

draft-wetterwald-detnet-utilities-reqs

Utility Use Case - What is your application?

- Increase Electric Grid Reliability / Optimization
  - ➔Support of Distributed Energy Resources
  - ➔Migration to Equipment supporting new Standards
    - IEC 61850 implies new real time communications requirements.
- Optimization of Telecommunications network ➔ Multi-Services network (Mission critical to work force management):
  - Transition from TDM to packet switching while keeping the deterministic behavior.

Infrastructure Footprint Hydro-Quebec example

514 substations
60 generating stations
143 administrative buildings
10,500 km of optical fibre
315 microwave links covering 10,000 km
205 mobile radio repeater sites

835 telecom sites across Québec

Electrical Transmission Network Characteristics

- Designed to transport over long distances
- Specificity and complexity of the separation between generation and load (~ 1200 km)
- Distance between substations (max 280 km)
- Interconnected with:
  - Ontario
  - New York
  - Nouvelle-Angleterre
  - Nouveau-Brunswick

Click to edit Master text styles

Second level

Third level

Fourth level

Fifth level

Hydro-Québec

How do you support the application today?

- Use of TDM networks:
  - Dedicated application network.
  - Specific calibration of the full chain (costly).
- No mixing of OT and IT applications on the same network.
- Migration to new IEC standards (61850) just starting.

What do you want to do differently in the future? What would you like the IETF to deliver?

- Use of Deterministic Networking technologies based on Open Standards for time critical applications.
- IT and OT convergence.
- L2 and L3 topologies.
- Centralized computing of deterministic paths (but distributed may be OK).

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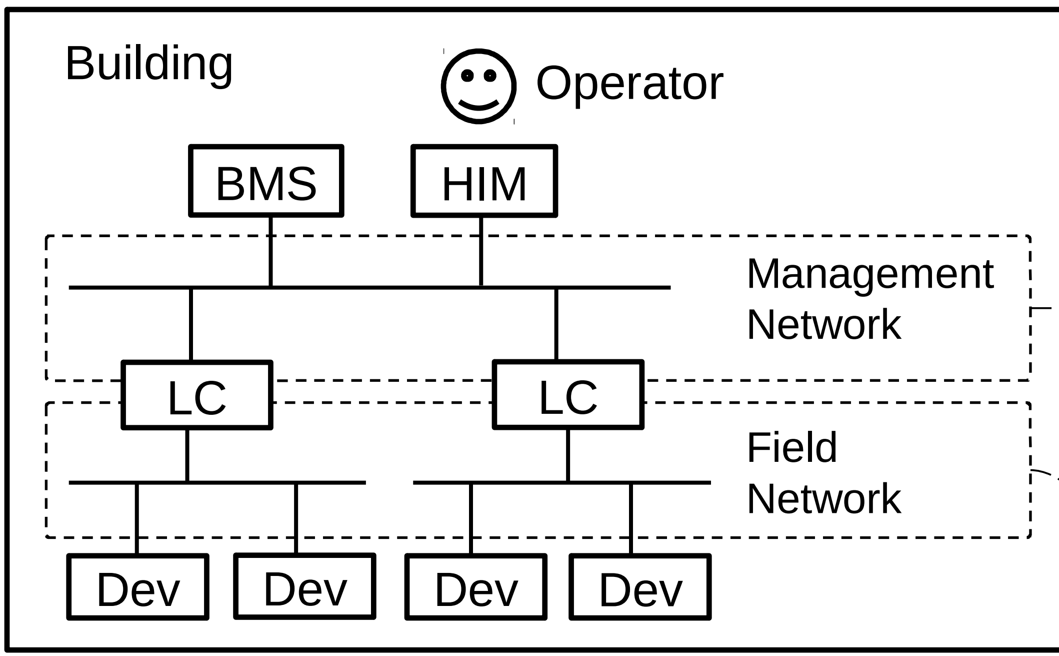
Deterministic Networking for Building Automation Systems (BAS)

What is your application?

- BAS is a system that monitors and controls states of devices.
  - sensors (e.g., temperature, humidity), room lights, doors, HVAC, FANs, valves.



Communication Cycle	1sec ~ 30min
Availability	99.999%

Communication Cycle	50msec ~ 200msec
Availability	99.9999%

BMS = Building Management Server

HIM = Human Interface Machine

LC = Local Controller

How do you support the application today?

- Management Network
  - IP-based protocol (e.g., BACnet/IP)
  - BMS and HIS are almost normal desktop servers
- Field Network
  - Non IP-based protocol (e.g., LonTalk, Modbus, proprietary protocols)
    - Each protocol achieves the field protocol requirements in its own specification
  - Local Controllers are specialized machine equipped with various interfaces (e.g. RJ-45, RS-485) and redundancy functionality at hardware level

What do you want to do differently in the future?

- There are many protocols in the field network
  - Different MAC/PHY specifications (Some of them are proprietary, some are standards-based)

  ⬇

  - Low interoperability, vendor lock in, high development cost for Local Controllers, need protocol translation gateways.

  ⬇

  - Expensive BAS

- Some field network protocols do not have security
  - It was may be ok when isolated but now things have changed
    - Example: Stealing TARGET (in US) credit card information

What would you like the IETF to deliver?

- An architecture that can guarantee: i) communication delay <50msec with several hundred devices; and ii) 99.9999% network availability.
    - An interoperable protocol specification that satisfies above timing and QoS requirements

Pascal Thubert

IETF 93

Prague, July 2015

Wireless for industrial applications Based on 6TiSCH

draft-thubert-6tisch-4detnet

What is your application?

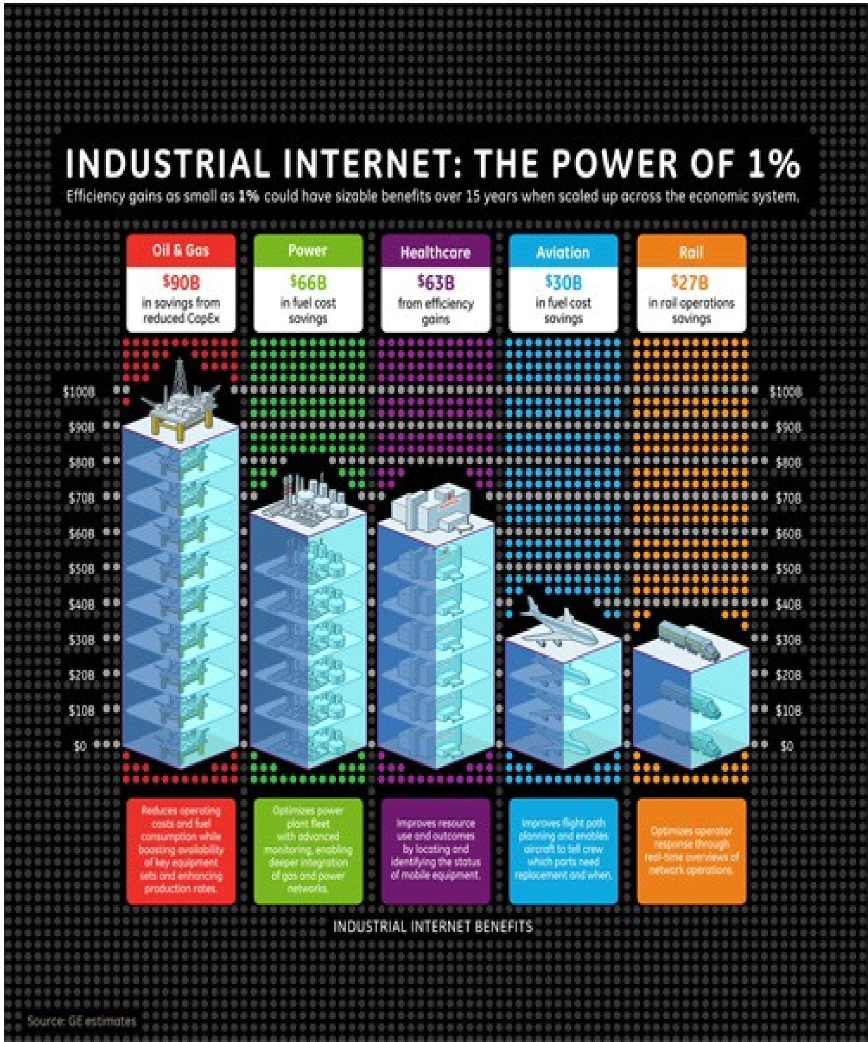
Industrial operators are after next % point of operational optimization:

Requires collecting and processing of live “big data”, **huge amounts of** missing measurements by widely distributed sensing and analytics capabilities.

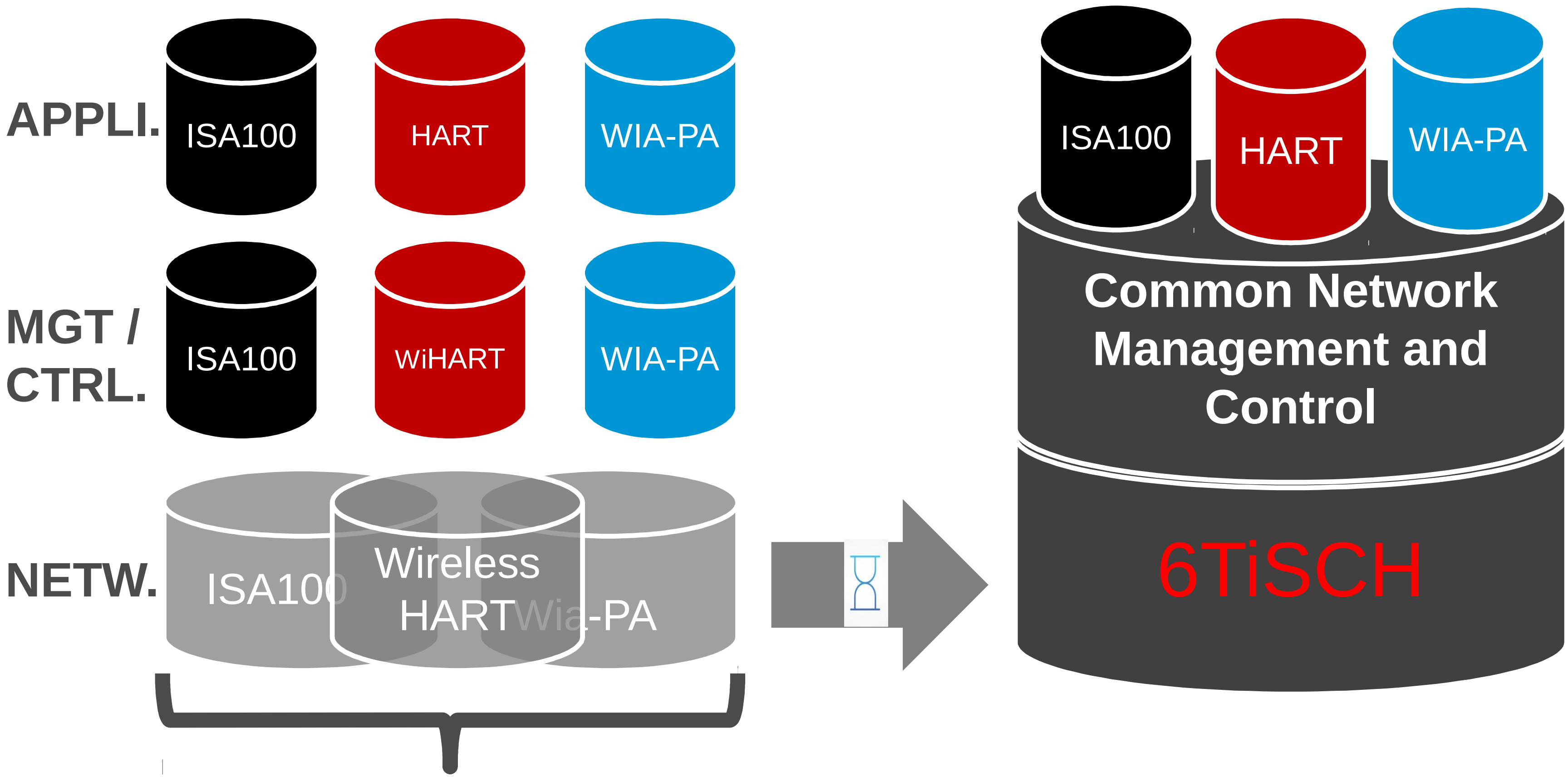
Sharing the same medium as critical (deterministic) control flows

IT/OT convergence, aka **Industrial Internet**.

The next problem is to extend Deterministic Industrial technologies to share bandwidth with non-deterministic traffic, reaching higher scales at lower costs.



How do you support the application today?



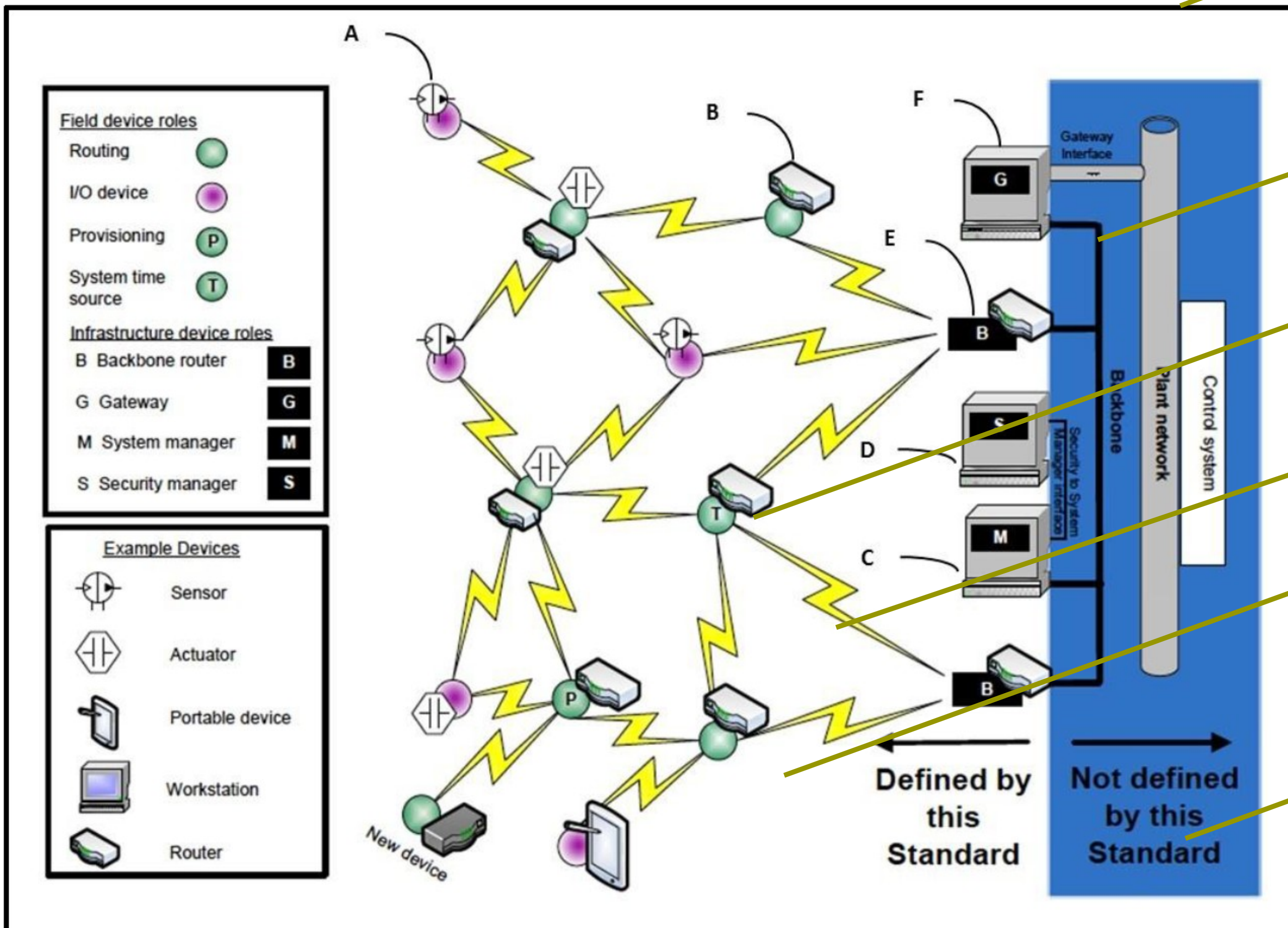
TRIPLE OPEX + interferences

Better Co-Existence

What do you want to do differently in the future?

- Hour glass model to replace silos
  - E2e principle, with one network, one network management, many applications
  - allowing evolution and dropping costs
- Open Protocols, Open source implementations
  - leveraging IETF, IEEE and ETSI
- Mix of deterministic and stochastic traffic
  - using IPv6 to reach widespread non critical devices for Industrial Internet
- Virtualized networks
  - with perfect isolation of IP flows vs. each individual (deterministic) control flow
- Deterministic properties spanning beyond wireless
  - over backbone to fog running virtual appliances

What would you like the IETF to deliver?



~~Silo~~ but open standards

End to end tagging

Replication & Elimination

Per-Flow State

IP routing (RPL) on same network

End-to-end deterministic in standard

Jouni Korhonen

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Deterministic networking for radio access networks

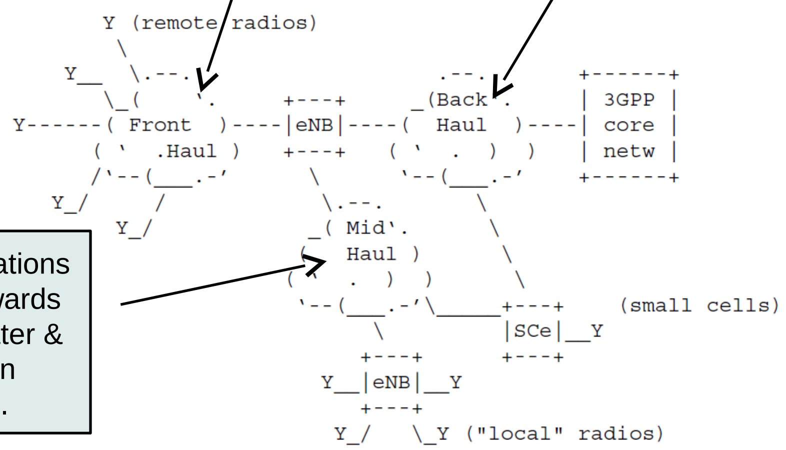
What is your application?

- Connectivity between the remote radios and the baseband processing units.
- Connectivity between base stations.
- Connectivity between the base stations & the core network..

Base band to radio heads – *very* *strict* latency & jitter and BER requirements. High BW needs. Precise synchronization.

Core to base station – business as usual so far. Latency becoming a concern.

Between base stations – developing towards tighter latency, jitter & synchronization requirements.



How do you support the application today?

- Front-haul:
  - Dedicated point-to-point fiber connection is a common approach.
  - Proprietary protocols and framings.
  - Custom equipment and no real networking.

- Mid-haul & Back-haul:
  - Mostly normal IP networks, MPLS-TP, etc.
  - Clock distribution and synchronization using, for example, 1588 and SyncE.

What do you want to do differently in the future?

- Unified standards based transport protocols and standard networking equipment – that can make use of e.g. underlying deterministic link-layer services.
- Use unified and standards based network management systems/protocols in all parts of the network.

What would you like the IETF to deliver?

- Standard for data plane transport specification:
  - Would be unified among all *hauls.
  - Can be deployed in the highly deterministic networking environment.

- Standard for data flow information model:
  - YANG data model(s) / augments that are aware of the time sensitiveness and constraints of the target networking environment.
  - Is aware of underlying deterministic networking services e.g. on Ethernet layer.

Summary – common themes

- Time sensitiveness:
  - Latency quarantee, guaranteed delivery, delay variation guarentee, ..
- Open standards:
  - Single solution – no more silos
  - Vendor interoperability
- A mix of different traffic types in the same network:
  - L2 and L3, L2 over L3, ..
  - Both deterministic and ”normal” traffic

Backup slides

Deterministic radios

Can we make radios deterministic?

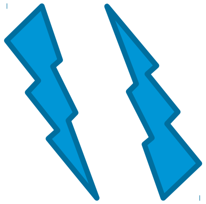
Controlling time of emission

~10µs sync on 802.15.4e TSCH

Can guarantee time of delivery

Protection the medium

ISM band crowded, no fully controlled



all sorts of interferences, including (mostly) self

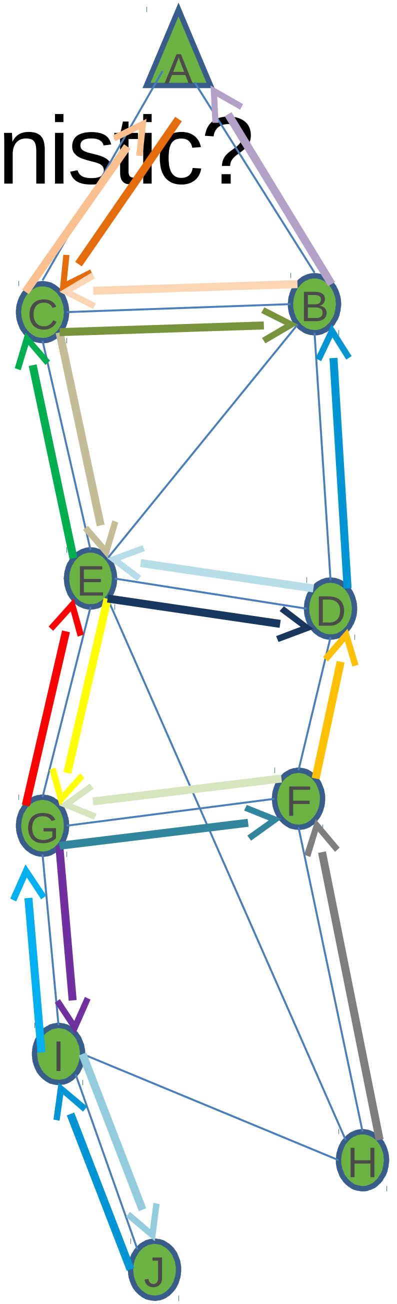
Can not guarantee delivery

Improving the Delivery ratio

Different interferers => different mitigations

Diversity is the key, use all possible

So how do we make wireless deterministic?



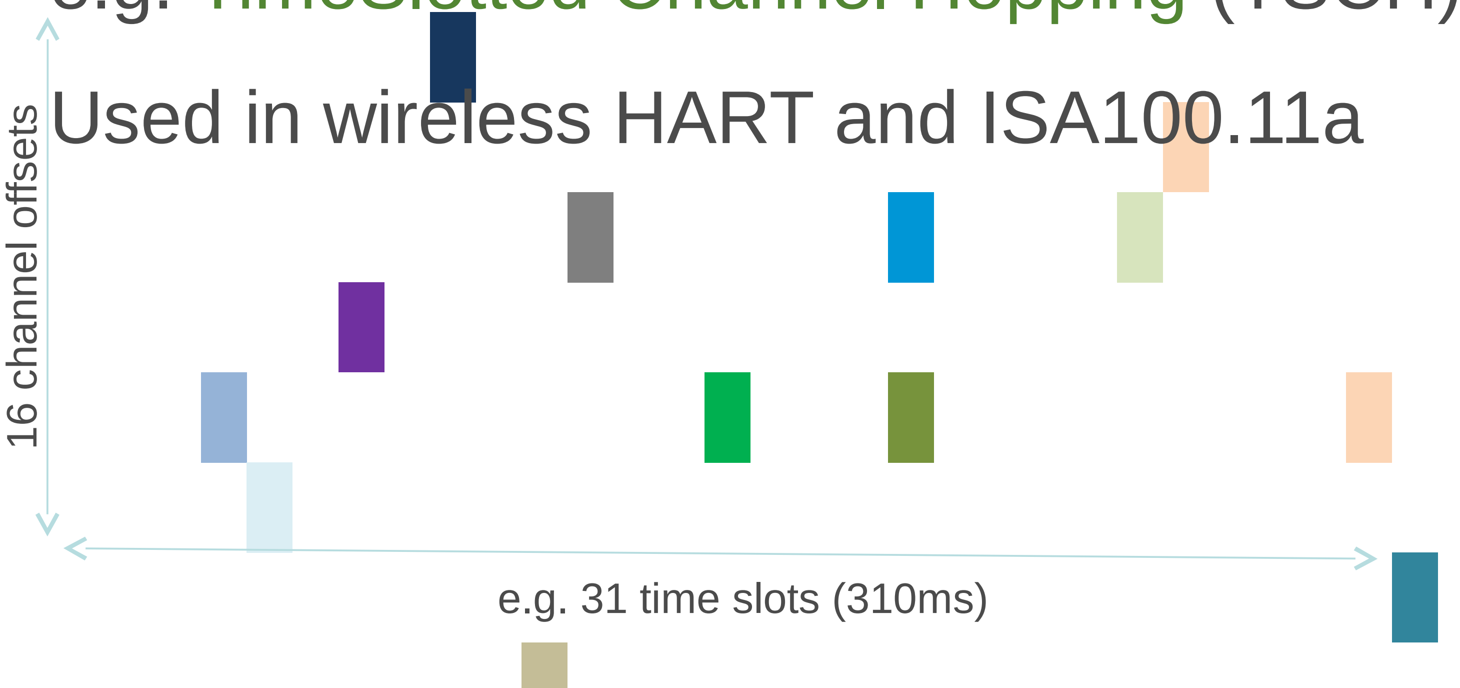
Schedule every transmission

to maintain the medium free at critical

times

e.g. TimeSlotted Channel Hopping (TSCH)

Used in wireless HART and ISA100.11a



Benefits of scheduling in wir

- Reduces **frame loss**
  - Time and Frequency Diversity
  - Reduces co-channel interference
- Optimizes **bandwidth usage**
  - No blanks due to IFS and CSMA-CA exponential backoff
  - While Increasing the ratio of guaranteed critical traffic
- Saves **energy**
  - Synchronizes sender and listener
  - Thus optimizes sleeping periods
  - By avoiding idle listening and long preambles

Key take-aways

Wireless can be made Deterministic and provide similar benefits as wired

- High delivery Ratio through path redundancy and collision elimination
- High ratio of critical flows
- Bounded maximum latency (and jitter)

Centrally scheduled operations bring additional benefits in wireless

- Medium usage optimization (no IFS, backoff, etc…)
- Energy savings (wake up on scheduled transmission)

But **how that is effectively achieved is** effectively **different** in wireless

- All transmission opportunities MUST be scheduled (not just deterministic ones)
- Reserved scheduled transmission opportunities for critical traffic
- Shared scheduled transmission opportunities & dynamic allocation for best effort

Enter 6TiSCH

What is 6TiSCH ?

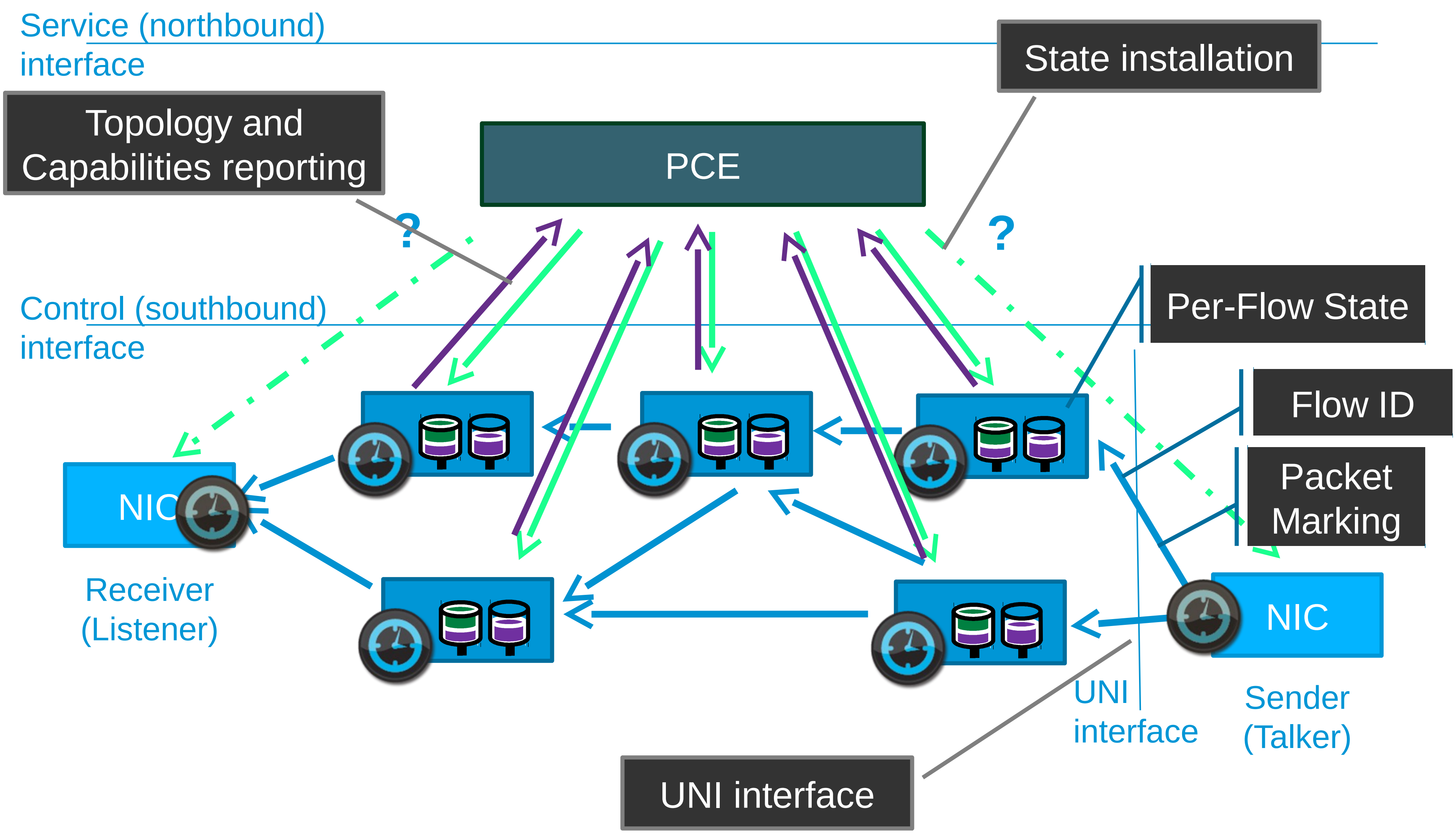
- 6TiSCH also specifies an IPv6-over-foo for 802.15.4e TSCH
  but does not update 6LoWPAN (that's pushed to 6lo).
  Rather 6TiSCH defines the missing Data Link Layer.
  - The 6TiSCH architecture defines the global Layer-3 operation.
  It incorporates 6LoWPAN but also RPL, DetNet (PCE) for deterministic networking, COMAN, SACM, CoAP, DICE …

=> Mostly NOT specific to 802.15.4 TSCH

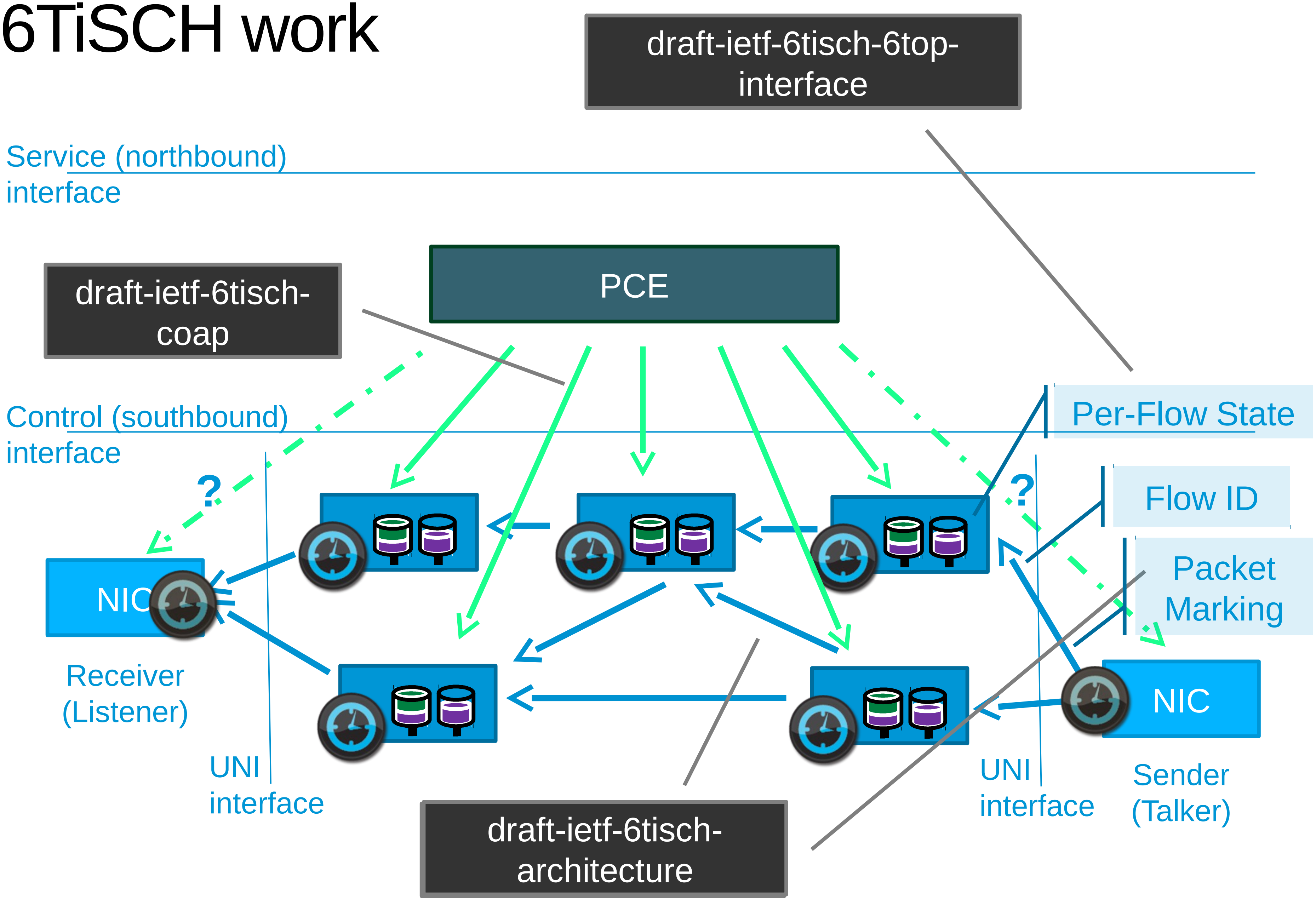
- Thus 6TiSCH has to make those components work together
  E.g. of work being pushed to other WGs:

http://tools.ietf.org/html/draft-thubert-6man-flow-label-for-rpl
http://tools.ietf.org/html/draft-thubert-6lo-forwarding-fragments
http://tools.ietf.org/html/draft-thubert-6lo-rfc6775-update-reqs

DetNet Scope

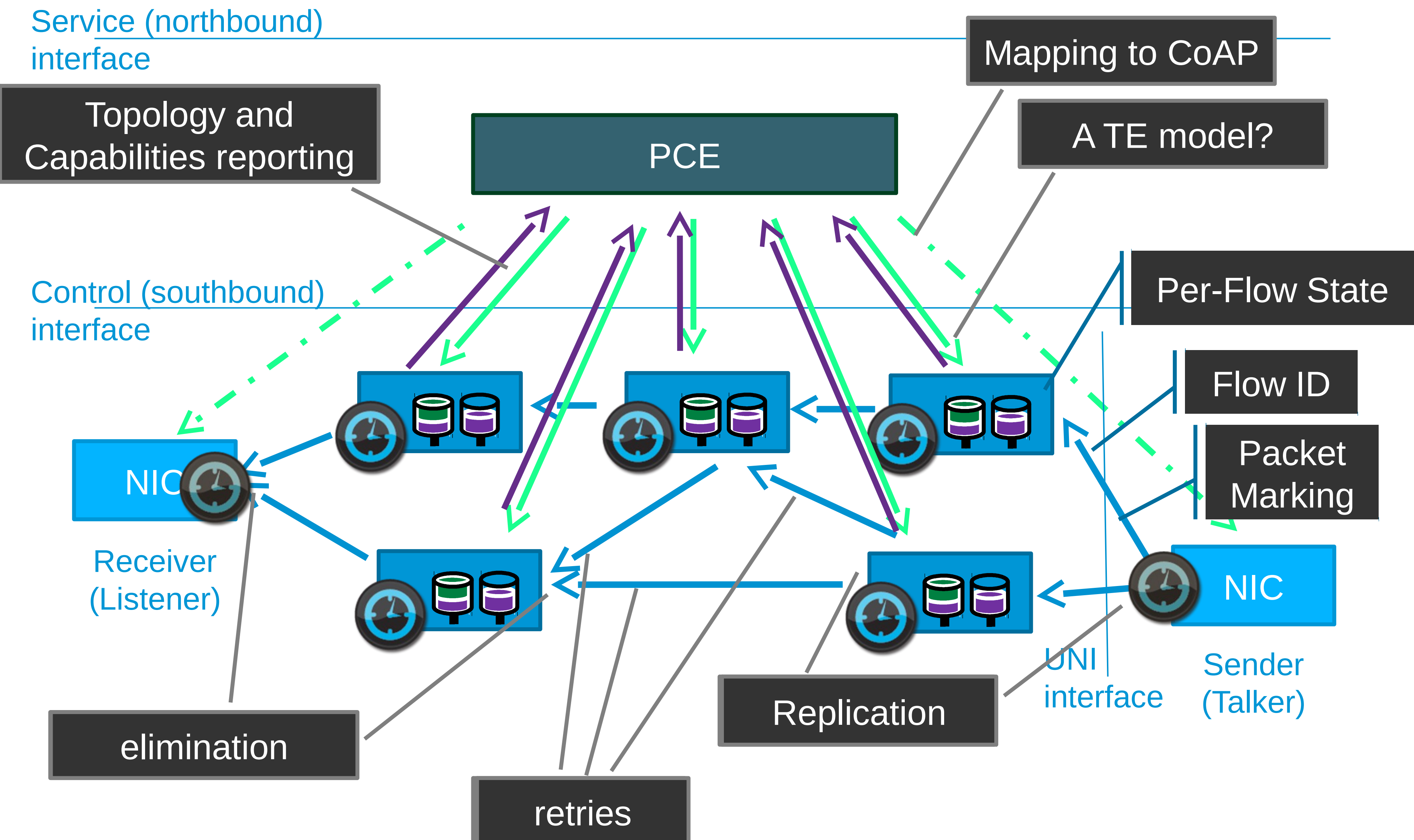


6TiSCH work



draft-ietf-6tisch-6top-interface
Service (northbound) interface
PCE
draft-ietf-6tisch-coap
Control (southbound) interface
Per-Flow State
Flow ID
Packet Marking
?
?
NIC
Receiver (Listener)
UNI interface
NIC
Sender (Talker)
UNI interface
draft-ietf-6tisch-architecture

6TiSCH needs



Key take-aways on

- Radio Mesh: Range extension with **Spatial reuse** of the spectrum
- Centralized Routing, optimizing for **Time-Sensitive flows**
  - Mission-critical data streams (control loops)
  - Deterministic reach back to Fog for virtualized loops
  - And limitations (mobility, scalability)
  - Distributed Routing for large scale monitoring (RPL)
  - Enabling co-existence with **IPv6-based Industrial Internet**
  - Separation of resources between deterministic and stochastic
    Leveraging IEEE/IETF standards (802.15.4, 6LoWPAN …)

Utilities requirements

Deterministic requirements

- Requirements are based on use cases, 2 main areas where deterministic communications are needed (mainly communication between Intelligent Electronic Devices “IEDs”):
  - Intra Substation Communications
  - Inter Substation Communications
- Information carried are instantaneous electrical information and real time commands:
  - Currents, Voltages, Phases, Active and Reactive power…
  - Trip, open/close relay…

  - Need to re-act in a fraction of a cycle (50 – 60 Hz). Be aware that most of the time is spent on opening or closing electrical lines (physical).

- Latency, Asymmetric delay, Jitter, Availability, Recovery time, Redundancy, Packet loss and precise timing being most important parameters.

- We are playing with lines moving electrical power with voltage level from 110 volts to 735 Kvolts. Power has to be transported by electrical lines not consumed.

See draft-wetterwald-detnet-utilities-reqs-02

Substation Automation

Applications	Transfer time (ms) (top of the stack to top of the stack)
Trips, Blockings	3
Releases, status changes	10
Fast automatic interactions	20
Slow automatic interactions	100
Operator commands	500
Events, Alarms	1000
Files, Events, log contents	> 1000

Time Synchronization: High synchronized sampling requires **1us** time synchronization accuracy

Based on IEC 61850 requirements

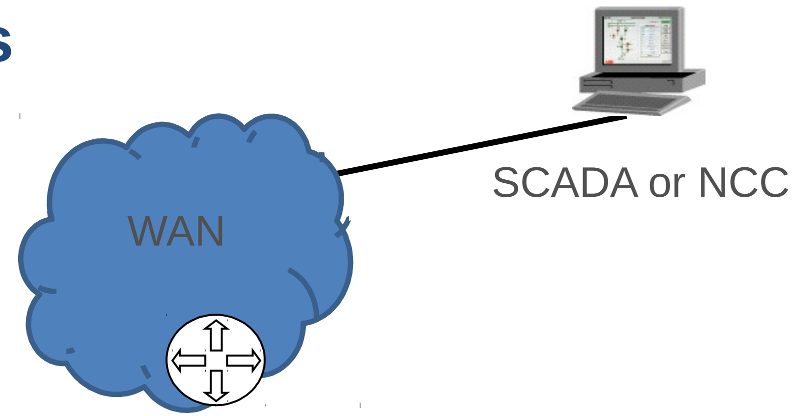
Substation Automation

Communicating partners	Application recovery delay (in ms)	Communication recovery delay (in ms)
SCADA to IED	800	400
IED to IED	12	4
Protecting Trip	8	4
Bus bar protection	< 1	Hitless
Sampled values	Less than few consecutive samples	Hitless

Use of redundant schemes mandatory for some use cases.

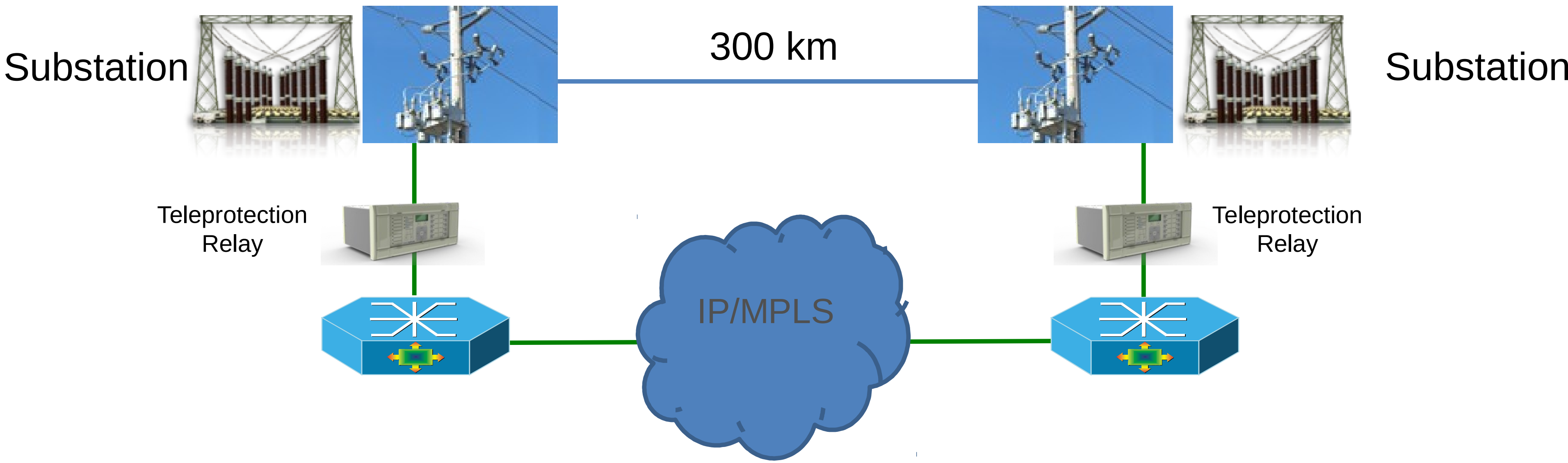
GOOSE and SV (Sample values) traffic in large substation could reach 900 Mb/s

typical Station / Process Bus



WAN requirements

- IEC 61850-90-12 covers WAN requirements.
- Current differential protection scheme (transmission):



Teleprotection use cases

Teleprotection requirement	Attribute
One way maximum delay	4-10 ms
Asymetric delay required	Yes
Maximum jitter	250 us
Topology	Point to point, point to multi-points
Availability	99.9999 %
Precise timing required	Yes
Recovery time on node failure	Hitless – less than 50ms
Redundancy	Yes
Packet loss	0.1 %

WAN Engineering Guidelines (IEC 61850-90-12) will address more detailed requirement
when available