DetNet Use Cases Overview

Ethan Grossman, Dolby Laboratories

DetNet – TSN Workshop

IETF 103, Bangkok

November 11, 2018

Use Case Authors

Pascal Thubert	(Cisco)	Wireless for Industrial
Craig Gunther	(Harman)	Professional Audio
Ethan Grossman	(Dolby)	
Patrick Wetterwald	(Cisco)	Electrical Utilities
Jean Raymond	(Hydro Quebec)	
Jouni Korhonen	(Broadcom)	Cellular Radio Access Networks
Maik Seewald	(Cisco)	
Bala'zs Varga	(Ericsson)	Industrial Machine-to-Machine (M2M)
Janos Farkas	(Ericsson)	
Juergen Schmitt	(Siemens)	
Franz-Josef Goetz	(Siemens)	
Subir Das	(Applied Comm Sci)	Building Automation Systems
Yu Kaneko	(Toshiba)	
Xavier Vilajosana	(Worldsensing)	Utilities - Wind Farm
Toktam Mahmoodi	(King's College London)	
Spiros Spirou	(Intracom Telecom)	
Petra Vizarreta	(Tech Univ Munich)	
Daniel Huang	(ZTE Corporation)	Private Blockchain
Xuesong Geng	(Huawei)	Network Slicing
Diego Dujovne	(Univ Diego Portales)	Mining

DetNet Use Cases

- Goals
- Use Cases
- Common Themes

DetNet Use Case Goals

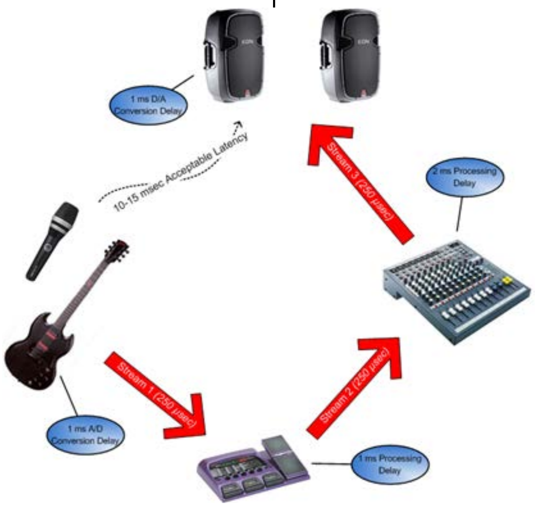
- Provide Industry context for DetNet goals
  - What are the use cases?
  - How are they addressed today?
  - What do we want to do differently in the future?
  - What do we want the IETF to deliver?
- Extract “Common Themes” of use cases
- Yardstick for functionality of any proposed design
  - To what extent does it enable these use cases?
- Does not
  - State specific requirements for DetNet
  - Suggest specific design, architecture, or protocols

Use Cases Overview

- Professional audio/video
- Electrical utilities
- Wind Farm
- Building automation systems
- Industrial Automation
- Industrial Wireless
- Cellular radio access networks
- Private Blockchain
- Network Slicing
- Mining

Professional Audio

- Music and Film Production Studios
- Broadcast
- Cinema
- Live (10-15ms worst case latency)
  - Stadiums, halls, theme parks, airports



Today

- Expensive proprietary networks
  - Intensive manual configuration of entire A/V network
  - Over provisioned bandwidth requirements
  - Separate networks for Data and A/V
  - Latency due to extra buffering (to avoid underruns)
- Separate AVB Layer 2 LANs
  - Can’t route over IP, thus hard to scale up

Pro Audio Future

- Share content between Layer 2 AVB segments within a Layer 3 intranet
  - 46 Tbps for 60,000 signals running across 1,100 miles of fiber
  - Geographically distributed
- Plug-and-play all the way up the protocol stack
  - Reduce manual network setup and admin
  - Allow quick changes in network devices and topology
- Re-use unused reserved bandwidth for best-effort traffic

Pro Audio asks from IETF

- Campus/Enterprise-wide (*think size of San Francisco*)
- Layer 3 routing on top of AVB QoS networks
  - Content delivery with bounded, lowest possible latency
  - Intranet, i.e. not the whole Internet (yet…)
  - IntServ and DiffServ integration with AVB (where practical)
- Single network for A/V and IT traffic
  - Standards-based, interoperable, multi-vendor
  - IT department friendly

Utility Networks

Example - Quebec

- **514 substations**
  - Max 280 km between 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**
- Carries instantaneous electrical information
  - Currents, voltages, phases, active and reactive power…
- Carries real-time commands
  - Trip, open/close relay…

Utility Networks 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

Utility Future

- Increase electric grid reliability / optimization
- Support distributed energy resources
- Move from TDM to Multi-Services network

Wind Farm Future

- Software-ization and virtualization of core wind farm equipment
  - (e.g. switches, firewalls and SCADA server components).
  - (SCADA == Supervisory Control and Data Acquisition)
  - Requires bounded latency and jitter, extraordinary low packet loss
- Example: Fail-over of a local SCADA server to a SCADA server in another wind farm site (under the administrative control of the same operator)
- In that case local traffic would be forwarded to the remote SCADA server
- Existing intra-domain QoS and timing parameters would have to be met

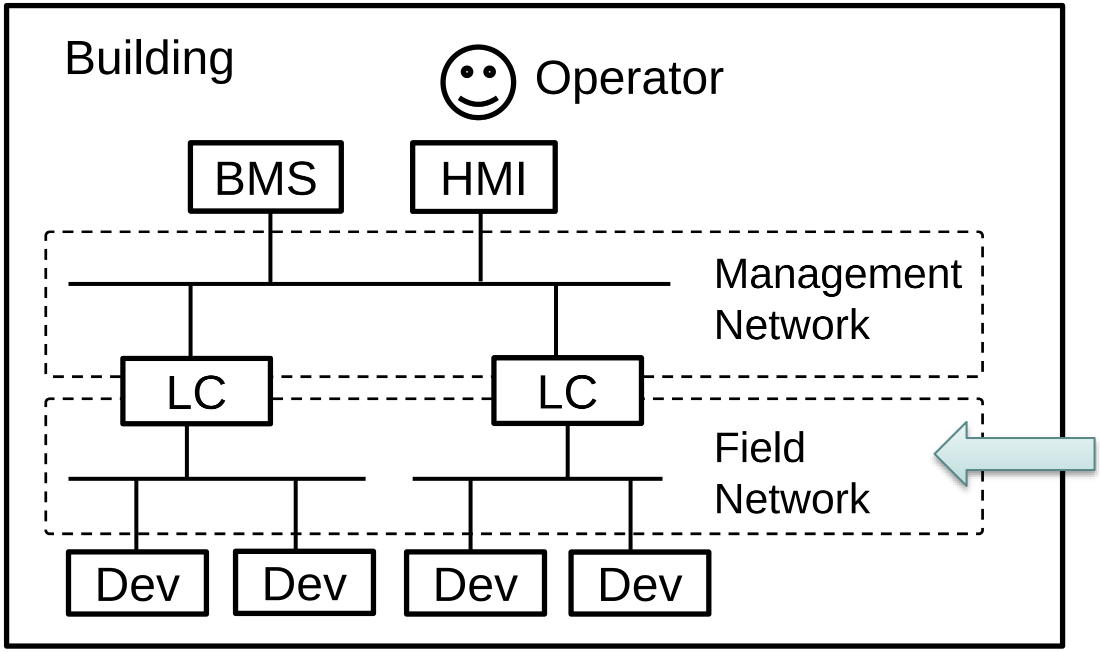
```
+--------------+
|              |
|              |
| Wind Park #1 +----+
|              |    |      XXXXXX
|              |    |      X    XXXXXXXX           +----------------+
+--------------+    |   XXXX          XXXXX      |                |
                    +---+      Operator    XXX     | Remote Control |
                        XXX    Administered   +----+     Center     |
                    +----+X    WAN         XXX     |                |
+--------------+    |    XXXXXXX             XX    |                |
|              |    |          XX     XXXXXXX      +----------------+
|              |    |            XXXXX
| Wind Park #2 +----+
|              |
|              |
+--------------+
```

Utility asks from IETF

- Mixed L2 and L3 topologies
- Deterministic behavior
  - Bounded latency and jitter
  - High availability, low recovery time
  - Redundancy, low packet loss
  - Precise timing
- Centralized computing of deterministic paths
  - Distributed configuration may also be useful

Building Automation Systems (BAS)

- Monitor and control the states of various devices
  - sensors (temperature, humidity), room lights, doors, HVAC, Fans, valves...



LC needs to communicate devices at each **10ms~100ms with 99.9999% availability** for feedback control and emergency control (e.g., fire detection)

BMS = Building Management Server

HMI = Human Machine Interface

LC = Local Controller

Building Automation Today

- There are many protocols in the field network
  - Different MAC/PHY specifications
    - Some proprietary, some 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
  - Not so bad when isolated but now things have changed
    - IT and OT are on the same internal network

Building Automation Future

- More and more sensors, devices
  - Large and complex networks
  - Fine grain environmental monitoring and control
    >> Reduction of energy consumption

- Connected to other networks (e.g., Enterprise network, Home network, Internet)
  - Better management of network to improve residents and operator's convenience and comfort
    - Control room lights or HVAC from desktop PC in office, Phone apps and so on
    - Monitor and control device status via the internet

BAS asks from IETF

- An architecture that can guarantee
  - Communication delay < 10ms~100ms with several hundreds of devices
  - 99.9999% network availability
    - detailed requirements depends upon BAS functions (environmental monitoring, fire detection, feedback control and so on)
- An interoperable protocol specification that satisfies the above timing and QoS requirements

Industrial Automation (M2M)

- Automation of manufacturing, quality control and material processing ("machine to machine" M2M)
- Machine in a plant floor exchange data with other machines and/or a supervisory controller
- M2M uses Programmable Logic Controllers (PLCs)

```
       S (Sensor)
        \
  PLC__  \.--.                   .--.
       \_(    `.               _(    `.
A------( Local  )-------------(  L2    )
      (      Net )           (      Net )    +----------------+
      /`--(___.-'             `--(___.-' ----| Supervisor PLC |
   S_/     /       PLC   .--. /              +----------------+
        A_/           \_(    `.
     (Actuator)       (  Local )
                     (       Net )
                      /`--(___.-'\
                     /       \    A
                    S         A
```

Current Generic Industrial M2M Network (LAN) Architecture

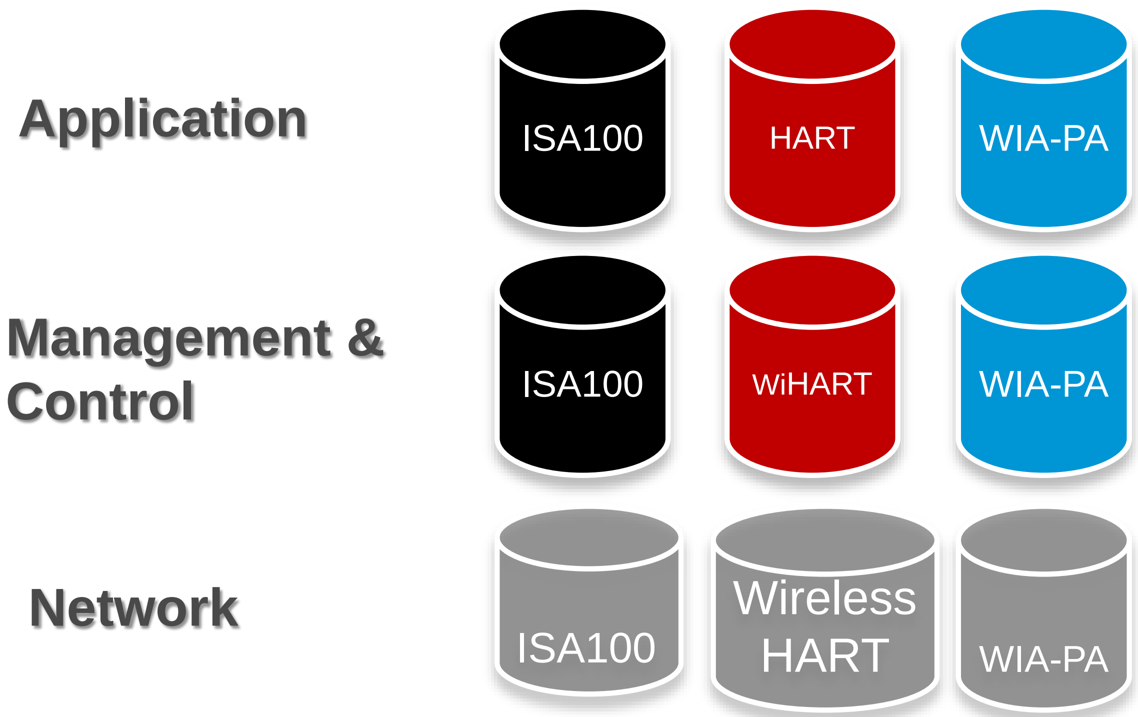
Wireless for Industrial

- Where wired is not an option
  - Rotating, portable, or fast moving objects
  - Resource-constrained (IoT) devices
- Real-time QoS required
  - Sensors and actuators
  - Control loops
- Huge networks, real-time big data
  - IoT, Factories
  - Distributed sensing and analytics
- Reliability, redundancy
- Security
- Huge, cost sensitive market
  - 1% cost reduction could save $100B

Wireless Industrial Today

Multiple deterministic wireless buses & networks

- **Incompatible with each other and with IP traffic**



Wireless Industrial future using 6TiSCH

- Unified network and management
  - Support deterministic and best-effort traffic
  - Wide Area, IP routing
  - Reduce cost – replace multiple buses
  - Enable innovation – optimize, gather previously unmeasured data
  - Leverage open protocols (IETF, IEEE and ETSI)
  - Use IPv6 to reach non-critical devices for Industrial Internet
- Use 6TiSCH for deterministic wireless
  - Time-Slotted Channel-Hopping Wireless MAC

Radio Access Networks

- 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.

```
          Y (remote radios)
           \
       Y__  \.--.                    .--.          +------+
           \_(    `.      +---+    _(Back`.        | 3GPP |
    Y------( Front  )----|eNB|----(  Haul  )----| core |
          ( `  .Haul )    +---+   ( `  .  )  )     | netw |
          /`--(___.-'       \      `--(___.-'      +------+
       Y_/     /             \.--.       \
            Y_/             _( Mid`.      \
                           (   Haul )      \
                          ( `  .  )  )      \
                           `--(___.-'\_____+---+    (small cells)
                                \          |SCe|__Y
                              +---+        +---+
                            Y__|eNB|__Y
                              +---+
                             Y_/   \_Y ("local" radios)
```

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

Radio Access Networks Today

- Front-haul (base band to radio)
  - Dedicated point-to-point fiber connection is common
- Back-haul (core to base station)
  - Mostly normal IP networks, MPLS-TP, etc.
  - Clock distribution and sync using 1588 and SyncE

Radio Access Networks Future

- Unified standards-based transport protocols and standard networking equipment that can make use of underlying deterministic link-layer services
- Unified and standards-based network management systems and protocols in all parts of the network

Radio Access Networks asks IETF

- A standard for data plane transport specification
  - Unified among all *hauls
  - Deployed in a highly deterministic network environment
- A standard for data flow information models that
  - Are aware of the time sensitivity and constraints of the target networking environment
  - Are aware of underlying deterministic networking services (e.g. on the Ethernet layer)

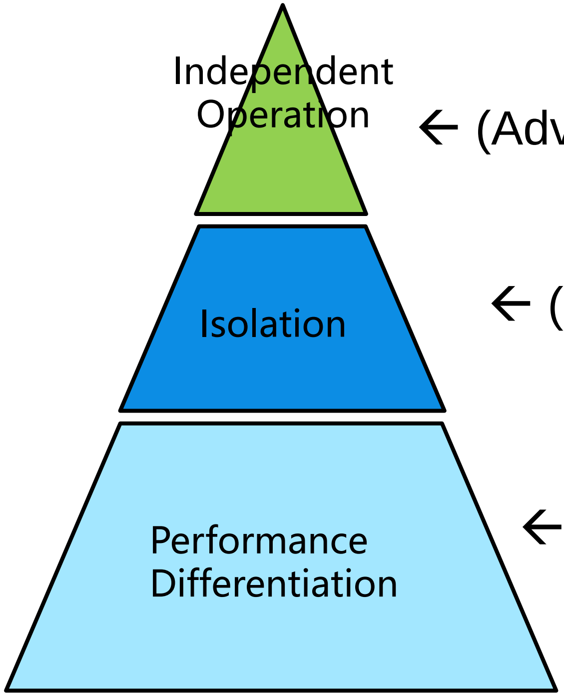
Private Blockchain Use Case

- ❑ Private Blockchain (corporate network)
- ❑ DetNet can
  - Accelerate consensus process
  - Facilitate point to multi-point traffic (vs. App layer)
  - Guarantee transport latency, negligible packet loss

- ❑ Private Blockchain Asks
- Layer 2 and Layer 3 multicast of blockchain traffic
- Bounded, low latency
- Negligible packet loss
- Coexistence of blockchain and IT traffic
- Scalable network with distributed control entities

Network Slicing Use Case

- **Network slicing** divides one physical network into multiple logical networks. Each slice, corresponding to a logical network, uses resources and network functions independently from each other.
- Network Slicing is a core feature of 5G defined in 3GPP (under development)



← (Advanced) Slice not impacted by, does not impact other slices

← (Core) Isolation (functional, performance, security)

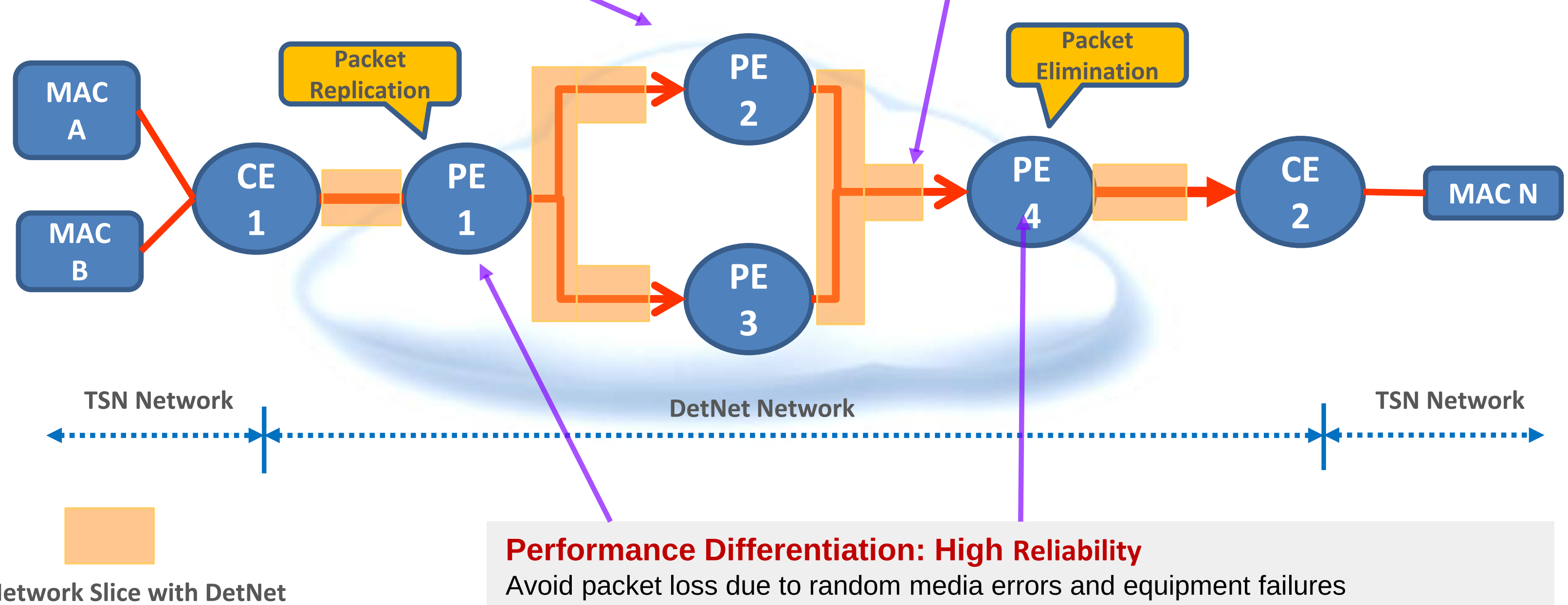
← (Basic) Bandwidth guarantee, low latency, low packet loss

DetNet in Network Slicing

Isolation: Functional, Performance, Security
Provide bandwidth reservation and flow isolation
Implemented with
- Resource reservation for DetNet flows
- Queuing management (shaping, scheduling)

Performance Differentiation: Service Customization
Specify explicit routes to control
- End-2-end latency
- Number of redundant trees

Implemented with
- Segment Routing
- RSVP-TE

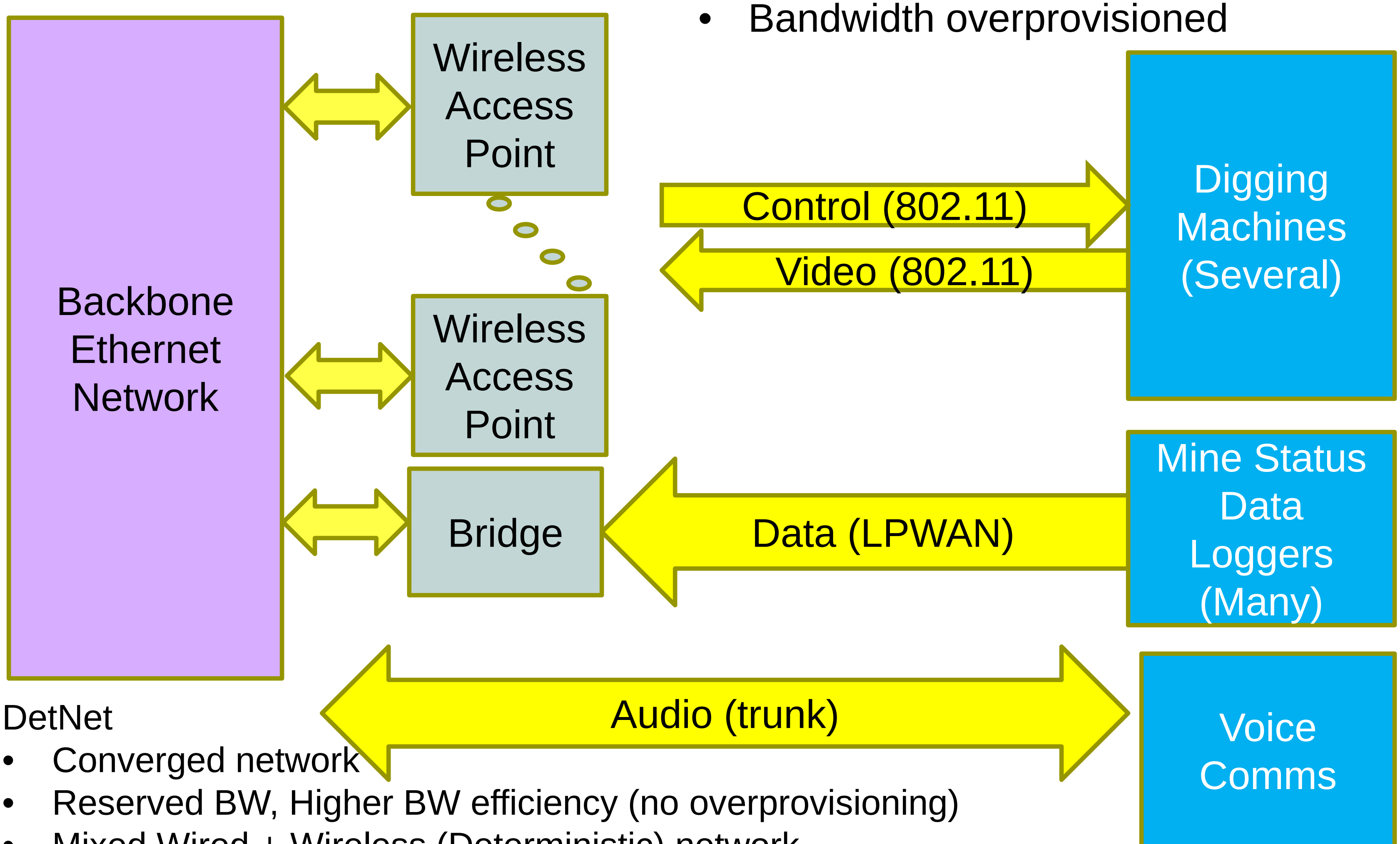


PE – Provider Edge Router
CE – Customer Edge Router
MAC – Media Access Control (address)

Performance Differentiation: High Reliability
Avoid packet loss due to random media errors and equipment failures
Implemented with
- Packet replication and elimination

Mining Use Case

Today
- Reliability via retries
- Latency tolerated
- Bandwidth overprovisioned



DetNet
- Converged network
- Reserved BW, Higher BW efficiency (no overprovisioning)
- Mixed Wired + Wireless (Deterministic) network
- Low Latency

Use Case Themes (1/2)

- Unified, standards-based network
  - Extensions to Ethernet (not a ”new” network)
  - Centrally administered (some distributed, plug-and-play)
  - Standardized data flow information models
  - Integrate L2 (bridged) and L3 (routed)
  - Guaranteed end-to-end delivery
  - Replace multiple proprietary determinstic networks
  - Mix of deterministic and best-effort traffic
  - Unused deterministic BW available to best-effort traffic
  - Lower cost, multi-vendor solutions

Use Case Themes (2/2)

- Scalable size
  - Long distances (many km)
  - Many hops (radio repeaters, microwave links, fiber links...)
  - Many flows
- Scalable timing parameters and accuracy
  - Bounded latency, guaranteed worst case maximum, minimum
  - Low latency (low enough for e.g. control loops, may be < 1ms)
  - Bounded Jitter
- High availability (may be 99.9999% up time)
  - Reliability, redundancy (lives at stake)
- Security
  - From failures, attackers, misbehaving devices
  - Sensitive to both packet content and arrival time
- Deterministic flows
  - Isolated from each other
  - Immune from best-effort traffic congestion