PVNO for Critical Infrastructure Reliability and Security

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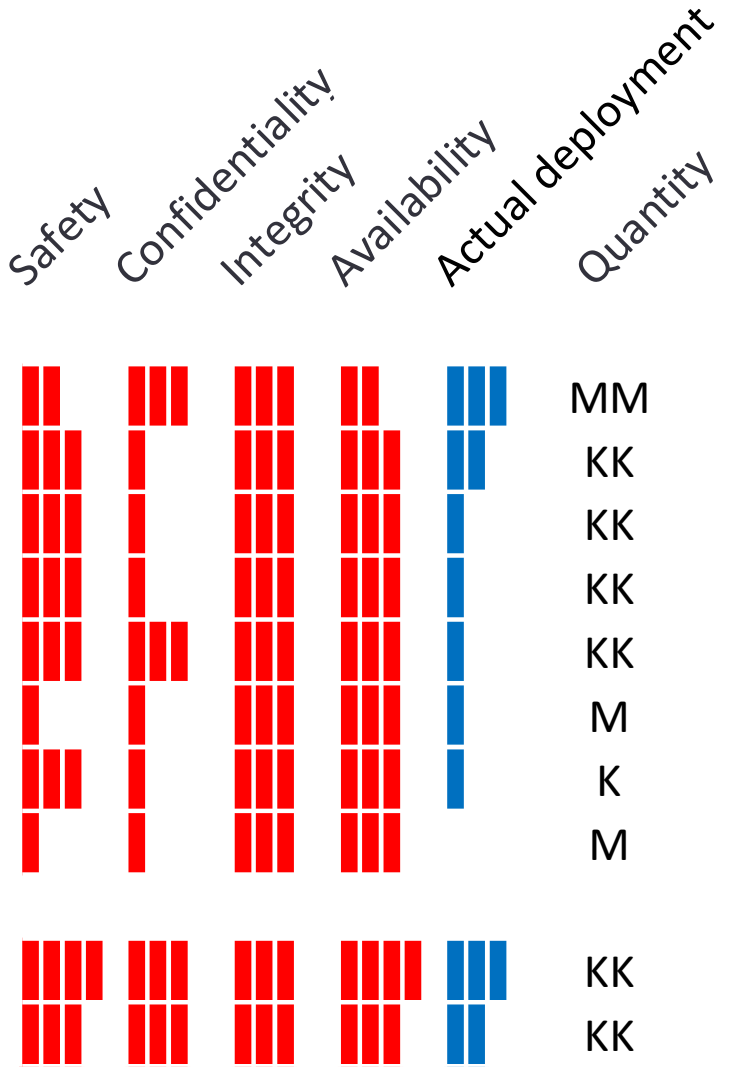
Agenda

- ❑ Critical Infrastructure Organization (CIO) Field Applications
- ❑ Current Commercial Cellular Pain Points & Architecture
- ❑ Potential Options
- ❑ PVNO Definition & Architecture
- ❑ Paving the Road to PVNO and Beyond
- ❑ Field Area Network Future
- ❑ Conclusion

Electric Utilities Field applications

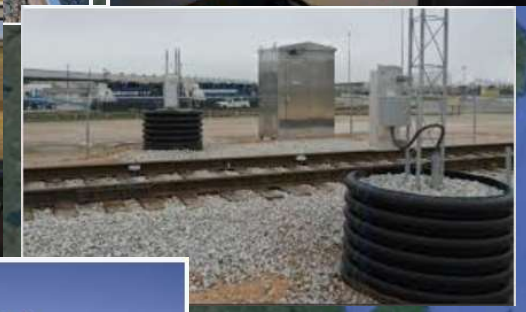
- Fixed - IIoT
  - AMI - Smart Meters
  - DA - Distribution automation (switches, reclosers)
  - FLISR – Fault Location and Restoration
  - Telemetry (Dam, Substation Yard, Distribution Grid)
  - DER - Distributed Energy Resources
  - DR- Demand Response
  - Microgrid
  - *Distributed Grid Stability Reserve (future)*
- Mobile - Workforce Management
  - LMR – Land Mobile Radio
  - Data - Dispatch, Work Orders, GIS



Rail Operational and Safety critical field applications

- Train Management and Dispatch
  - CTC (Centralized Train Control)
- Preventive Maintenance
  - HBDs (Hot Box Detectors)
  - “Machine Vision” portals
  - WILD (Wheel Impact Load Detector)
- Consist Verification
  - AEI (Automatic Equipment Identifier)
- Track Verification
  - Autonomous Track Inspection
  - Autonomous Track Geometry Measurement
- Advanced Train Control
  - WIUs (Wayside Interface Units)
  - ETMS (Electronic Train Control Management System - Onboard Systems)
- Passenger Connectivity
  - Essential Best Effort Based and Emergency calling




Commercial Cellular Service Pain Points

SIM cards: Complex device and SIM management
Subscription base

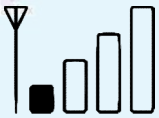
SIM lock-in: Changing carrier SIM requires a visit to every site ($$$)

Network: Complex IP and APN management

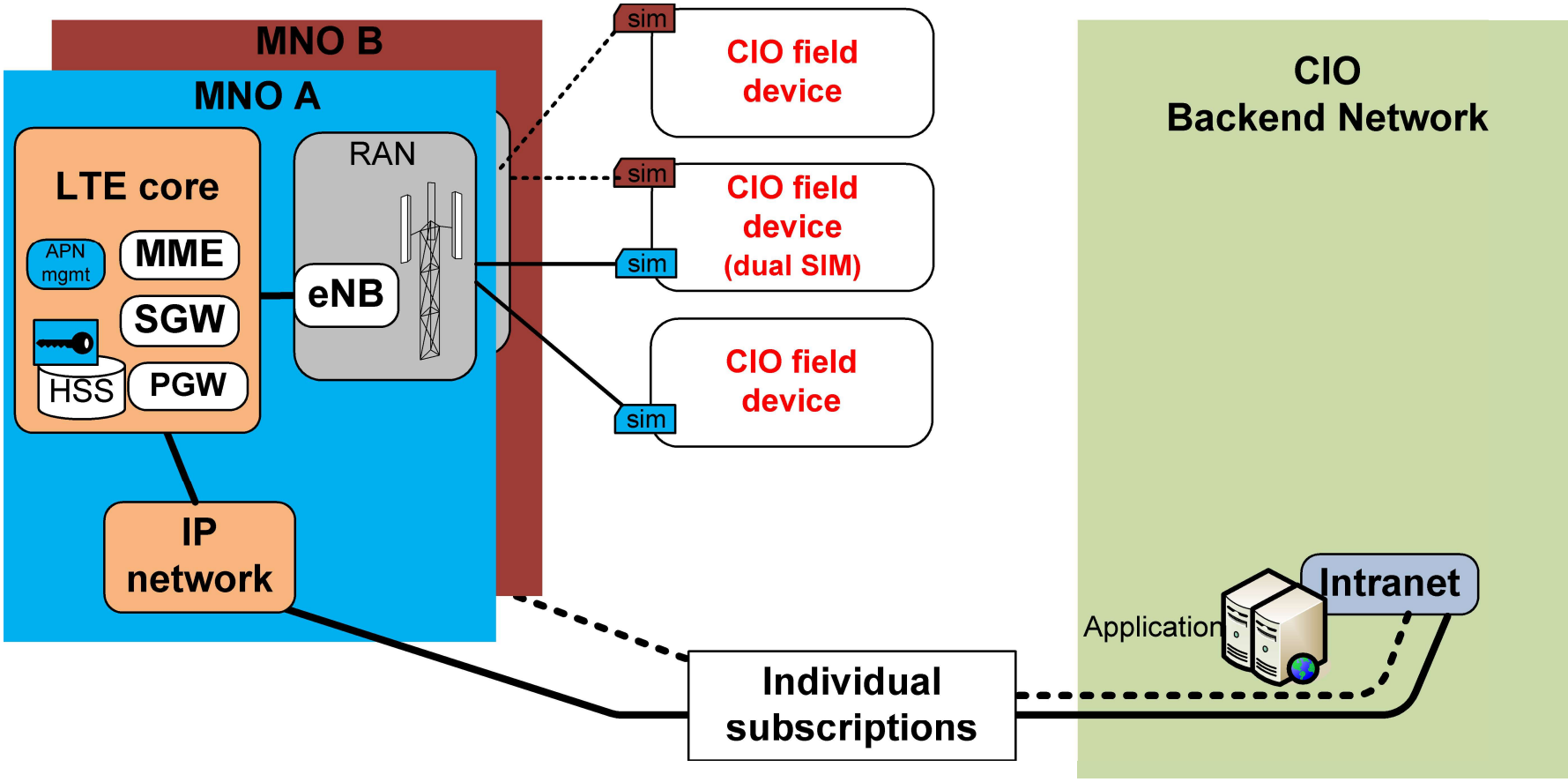
Security: Authentication element (HSS and PGW)
and SIM credentials are owned by the carriers

Reliability: Real-time carrier diversity(failover) requires multiple SIMs subscriptions with different IP addresses, more expensive multi-SIM devices ($$$)

Coverage: Limited to the operator's coverage (98% of pop. according to CTWA)
No incentive for expansion.
Largely underserved CIO territory (Remote Rural)



Current Commercial Cellular Architecture



Potential Options

	Dedicated APN with SIM cards (actual)	Dedicated APN with eSIM + PGW	Non-3GPP Private FAN (WiMAX, LoRa, …)	PVNO
Reliability				
MNO / vendor lock-in				
Security				
CAPEX + OPEX				
Coverage Expansion Potential				
Interoperability with PSBN				

eSIM: Multi-profile reprogrammable SIM (card, chip, soft.)
PGW: Packet Gateway

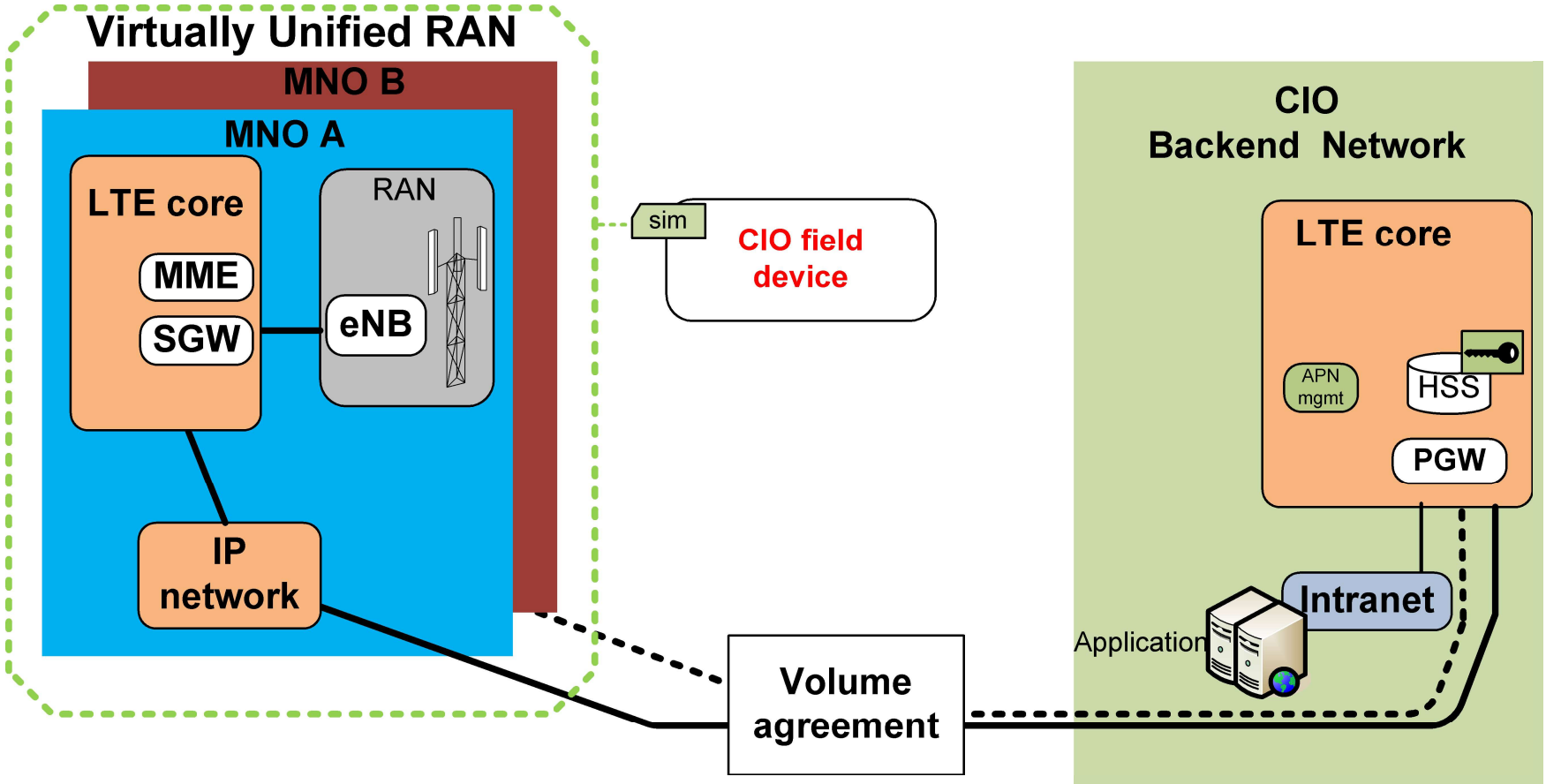
What is PVNO?

PVNO = Private Virtual Network Operator

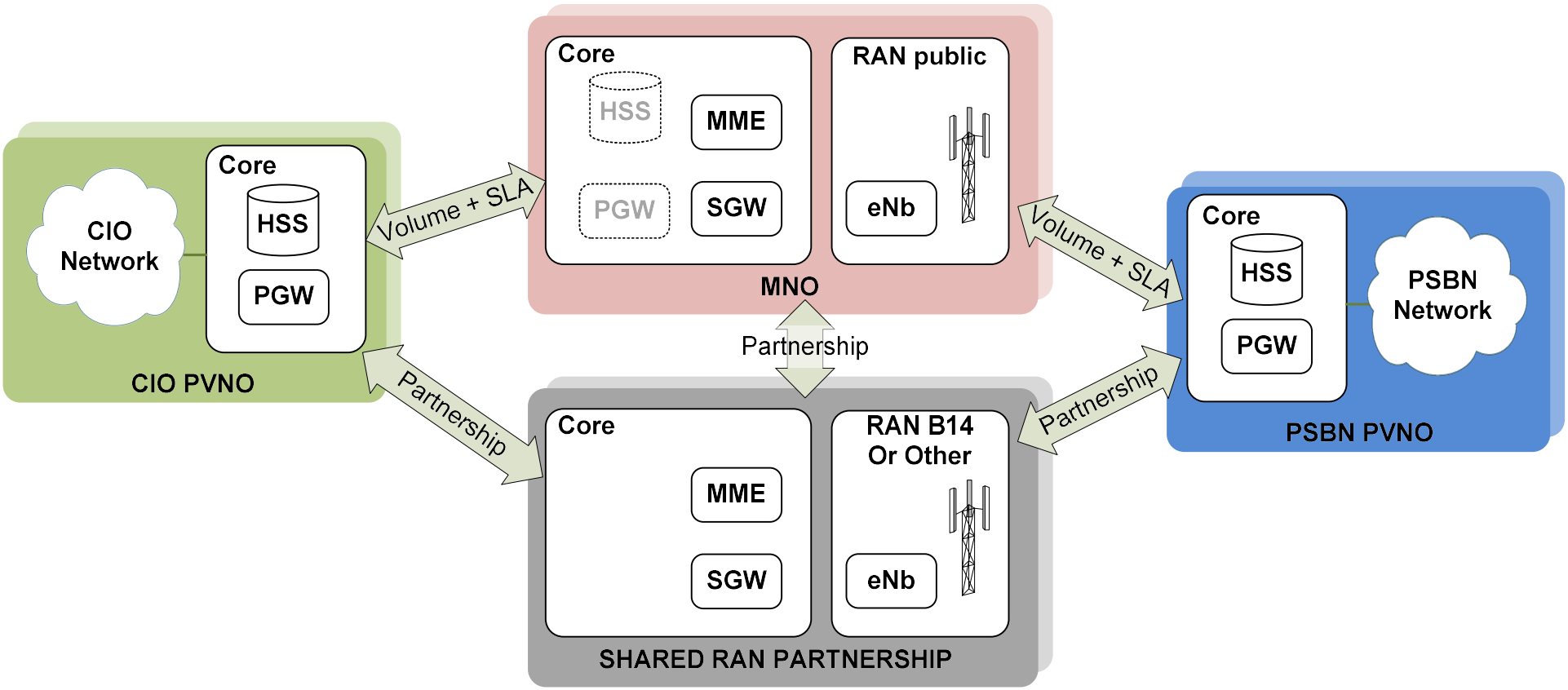
PVNO is a « Full-MVNO » as per Telecom Decision CRTC 2015-496, but exclusively for ClO's own operational needs

- Doesn't own a frequency licence;
- Frequency bands and RAN are provided by at least one MNO or other partners (ex: PS B14 + Shared RAN);
- Doesn't resell commercial cellular services to the general public (as opposed to Full-MVNO);
- Must own/rent a cellular packet core (like Full-MVNO);
- Use its own network subscription identifier SIM cards/IMSI number (**MNC required**);

PVNO Architecture



PVNO integration with Shared RAN and PSBN



Paving the road to PVNO and beyond

1. **Break MNO's chain - SIM cards lock-in : eSIM**
   - ❑ Ability to change remotely MNOs as needed.

Possible Now

2. **Control of wireless IP addresses and APN : PGW**
   - ❑ Change MNOs while maintaining IP addresses (IP anchor point).
   - ❑ Encrypted Interface between CIO and MNO (IPSec).

3. **Control of security keys + RAN diversity : PVNO**
   - ❑ Volume agreements with MNOs.
   - ❑ Use CIO credentials on the eSIM (IMSI/**MNC**, keys).

Regulatory challenges

4. **Expand coverage in partnership: SHARED RAN**
   - ❑ Invest where it matters… where MNO's don't go.
   - ❑ **Access to Broadband Frequency** is the challenge !

Field Area Network's future is 3GPP

- **PS/CIO requirements are being added since release 13 (Push-to-talk, QoS, …)**
- **PVNO Integrates with other technologies (WiFi, Multefire, …)**
  - MNOs already offload cellular traffic to Wi-Fi… also possible with a PVNO
- **Within 5-10 yrs – LEO/vLEO Satellite:**
  - Multiple Low Earth Orbit satellite networks will be in service (Telesat, SpaceX, OneWeb, …).
  - Coverage will be ubiquitous and performance shall be similar to LTE
  - Seamless integration with cellular and PVNO (3GPP release 15)
- **Within 10-20 yrs:**
  - Smart Meters will be replaced, and include LTE-M, NB-IoT.
  - LMR Narrow-Band network will be replaced by push to talk VoLTE.
  - Next Generation Smart Transportation Systems
- **Evolution to 5G / Network slicing / SDN / SDWAN / Edge computing**

PVNO + Shared RAN is a win-win for everyone

Critical Infra. Operators

- ↑ Reliability
- ↑ Security
- ↑ Coverage
- ↑ Innovation
- ↓ Costs
- ↑ QoS
- ↑ Safety
- ↑ Shared RAN
- ↑ Process efficiency
- ↑ No Vendor lock-in

Public Safety

- ↑ Reliability
- ↑ Security
- ↑ Coverage
- ↑ Technolology
- ↓ Costs
- ↑ QoS
- ↑ Safety
- ↑ B14 optimal use
- ↑ Process efficiency
- ↑ No Vendor lock-in

MNOs

- ↑ Revenues
- ↑ Traffic
- ↑ Innovation
- ↑ Freq. ROI
- ↑ New services (SLA)
- ↑ Coverage incentive
- ↑ Reliability incentive
- ↑ Business efficiency

Society and Governments

- ↑ Coverage (Rural & Others)
- ↑ Optimal use of public ressource (Frequency)
- ↑ Efficient use of public funds
- ↑ Safer and Reliable services (Electrical Utilities, Rail)

Conclusion

- Electric Utilities and Rail are critical infrastructure industries essential to Canada's public safety and economic well-being
- CIOs will be better served with PVNO
  - Improved reliability and security
  - Innovation enabler for smart grid and rail industry
- Technology is available and based on industry standards
- Regulatory challenges need to be addressed
  - CIO's access to an MNC as PVNO
  - CIO's ability to participate in a Shared RAN with access to spectrum

Thank you !

BACKUP

CIO/PS PVNO around the world

Europe

2014-03 Netherlands: Amended its IMSI numbering plan to allocate an MNC for CIO/PS and another for Industrial sector

- ❑ Motivated by Enexis utility deployment of smart metering and issues about SIM card lock-in
- ❑ Enexis world's first PVNO with one MNO was put in service in nov. 2015.

2015-08 Italy: Enel applied for an MVNO license for its private use (metering data)

- ❑ Enel concluded an exclusive wholesale agreement with TIM (major MNO in Italy).

Australia

2018-10 RFP issued by NSW Telco Authority for a National Public Safety Mobile Broadband POC.

- ❑ PVNO model with multi-carrier in metro and regional areas. + RAN sharing model for coverage expansion.
- ❑ Input for Australian future national PSBN

Canada

2012-2014 Joint publication IREQ - Ericsson on LTE for Smart Grid [IEEE Canadian review, spring 2014].

- ❑ Covers utilities concerns and approaches including PVNO and shared RAN scenarios.

2018-10 CEA request CRTC to grant a shared MNC and associated reliefs (PVNO)

- ❑ CRTC encourage CEA to wait for the 2019-2020 wireless framework review.

CIOs steps toward PVNO and beyond (1/2)

1. Break MNO's SIM cards lock-in : eUICC

- ❑ Get CIO eSIM + GSMA Subscription Management Service Provider
- ❑ Ask MNOs for eSIM integration service
- ❑ Replace existing MNO's SIMs by CIO eSIM with an MNO profile

Benefit:

- ❑ Remotely on demand change MNOs on each device

2. Get control of your wireless IP addresses and APN : PGW

- ❑ Acquire PGW (on-premises or as a service)
- ❑ Ask MNOs to route CIO APN traffic to the new PGW

Benefits:

- ❑ Complete control over the IP addressing
- ❑ Change MNOs and keep IP addresses (IP anchor point)
- ❑ Security: IPSec Transport between CIO PGW and MNO SGW

CIOs steps toward PVNO and beyond (2/2)

3. Control security keys + Active-Active MNO diversity: PVNO

- ❑ Get an IMSI range within CIO shared MNC
- ❑ Acquire HSS (on-premises or as a service)
- ❑ Remotely OTA replace on the eSIM the MNO profile by CIO's (IMSI + keys)

Benefits:

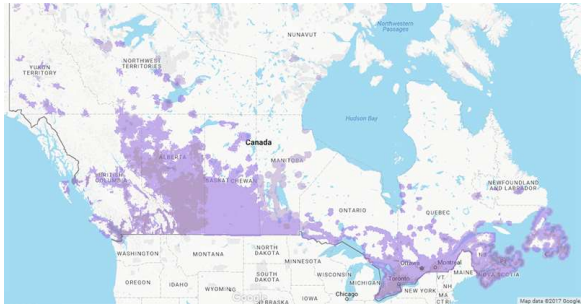
- ❑ Complete control of the security keys and improved reliability + robustness

4. Expand coverage where needed : SHARED RAN

- ❑ Get in partnership, sponsorship with others (CIO, Muni, PS, MNO, …)
- ❑ Built with CIO / PS reliability requirements

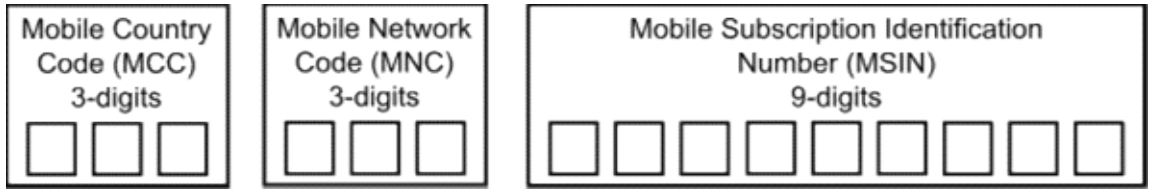
Benefits:

- ❑ Investments where it matters
- ❑ Leverage and efficient use of CIO funds
- ❑ Contribute to CIO social responsibility



What is IMSI / MNC

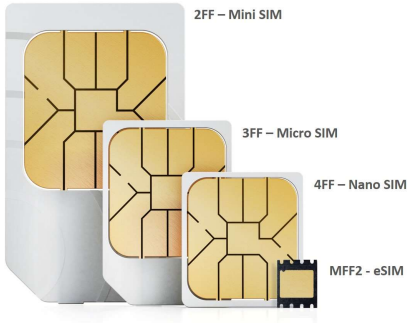
International Mobile Subscription Identity



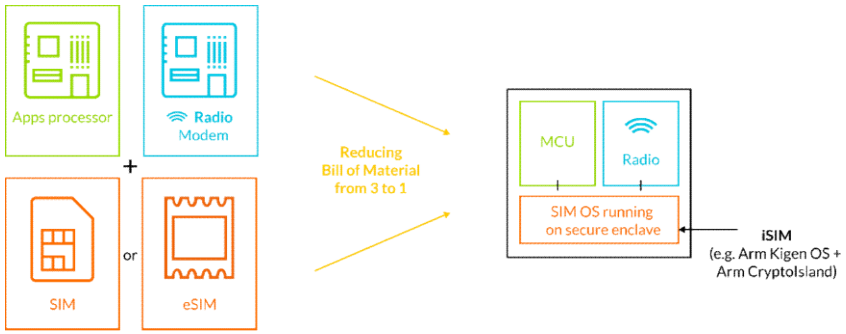
- Uniquely identifies user subscription to cellular network (MNC) and country (MCC) (also used by satellite and Tetra terminals)
- Conforms to ITU E.212 numbering and part of 3GPP std.
- CNA allocates MNC to operators according to CRTC guidelines http://www.cnac.ca/other_codes/imsi/imsi_codes.htm
- Canada MCC is 302
- Currently 2 digits MNC are allocated by CNA (roaming compatibility with GSM in Europe)
- Each 3 digits MNC has **1 Billion** possible subscription
- Part of in the service provider profile stored on the SIM/eSIM (with the encryption key)

eSIM a.k.a. eUICC

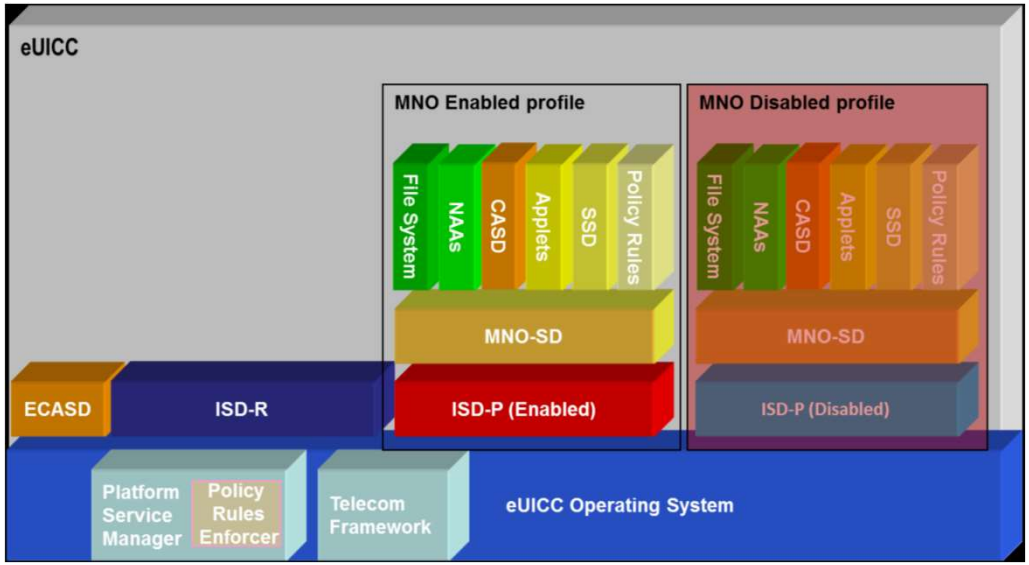
Physical form factors



ARM iSIM – IoT futur is now



Information within eUICC



- **NAA (Network Access Application)**
  - Contain the Network Access Credentials (IMSI, Ki/K keys)