5G Implementation of a CIP Motion Network

Rob Lodesky
HMS Industrial Networks

Wireless Adoption

- Cable Maintenance
- Future proof
- Upgrade cost

Wireless Challenges

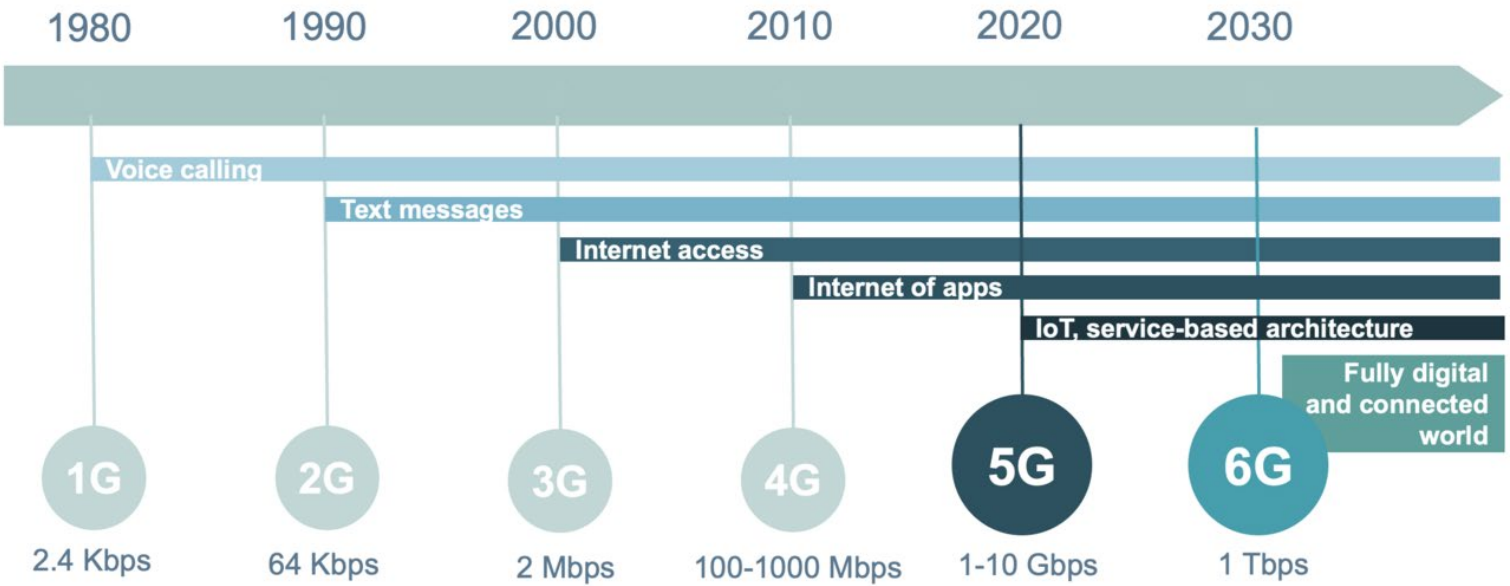
- Dynamic Site Survey
- Complex, or, at least, foreign setup
- Unfamiliar maintenance & troubleshooting
- High capital cost

Narrow support

	Use case	Category
1.	Connectivity for the factory floor	Hard RT
2.	Seamless integration of wired and wireless components for motion control	Hard RT
3.	Local control-to-control communication	Hard RT
4.	Remote control-to-control communication	Soft RT
5.	Mobile robots and AGVs	Soft RT
6.	Closed-loop control for process automation	Soft RT
7.	Remote monitoring for process automation	Non-RT

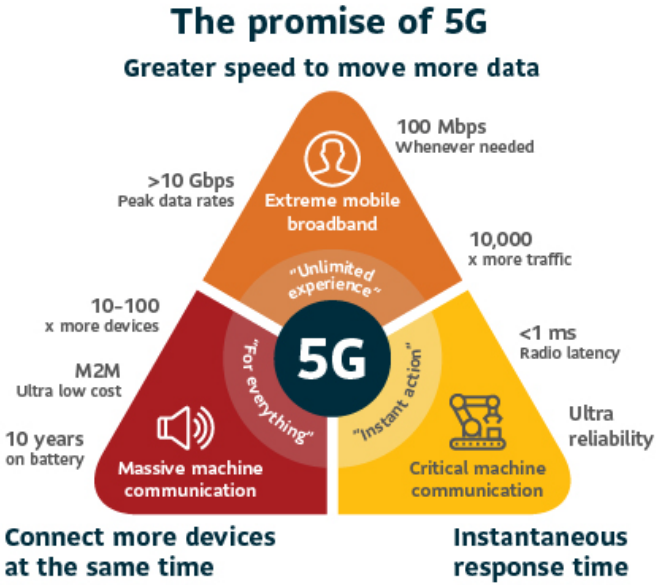
Non-RT: Cycle times and latency are not critical; several seconds are regarded as sufficient
Soft RT: Cycle times and latency are moderately critical, i.e. approximately one second
Hard RT: Cycle times and latency are highly critical, to within milliseconds or even microseconds

3GPP timeline



Built for Latency, finally

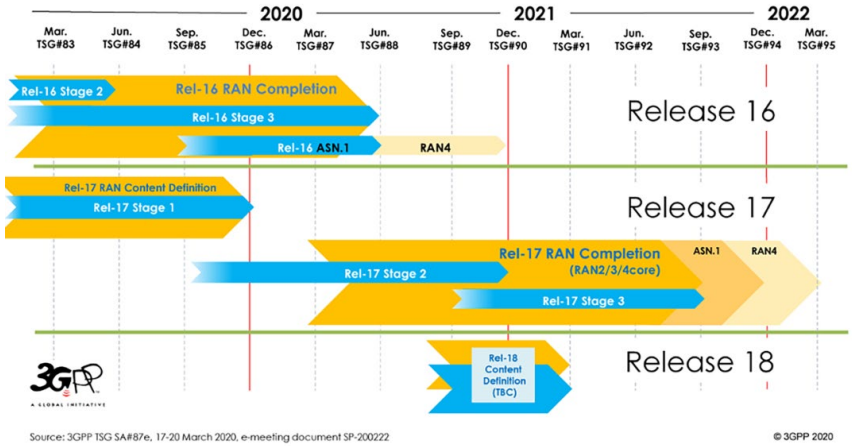
- Release 17 pointedly added IEEE 1588 PTP support
- DetNet and other deterministic protocols looking into 5G as well.



Release Schedule

- Release 16
  - Multi-sensor enhancements
  - Sidelink enhancements
  - millimeter wave (mmW) range support.
  - Some TSN support
- Release 17
  - 1588 support

Pandemic delays



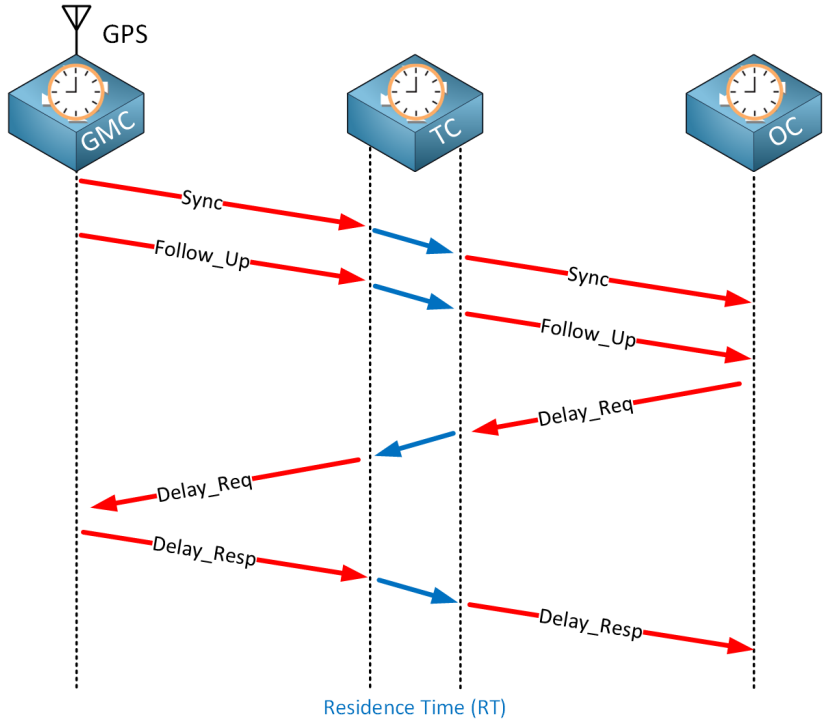
CIP Motion

- CIP Sync Integration
- Timestamping for determinism
- Decoupling Communication from Execution

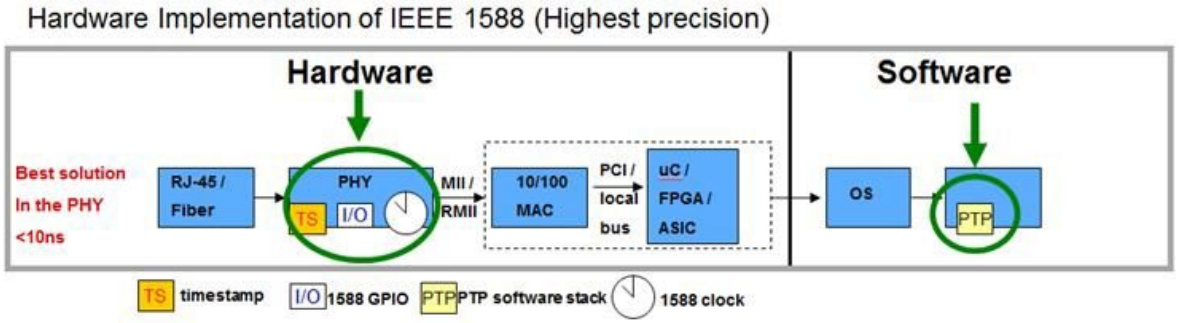
GMC = Grand Master Clocks

TC = Transparent Clocks

OC = Ordinary Clocks



- Time Stamps
  - Software Time Stamp
    - Millisecond level
  - Hardware Time Stamp
    - Nanosecond level
    - Costly

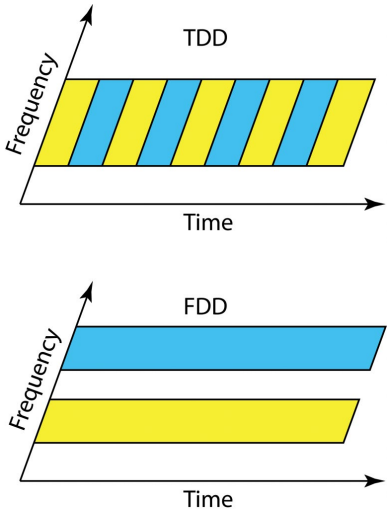


CIP9

- CIP9
  - Ericsson's 5G Time synchronization services
  - Critical Infrastructure Platform 9
  - Uses several protocols to ensure
    - synchronization between elements
    - Time Division Duplex (TDD)functionality
  - Functions include
    - PTP (Precision Time Protocol)
    - TCC (Time Critical Communication)

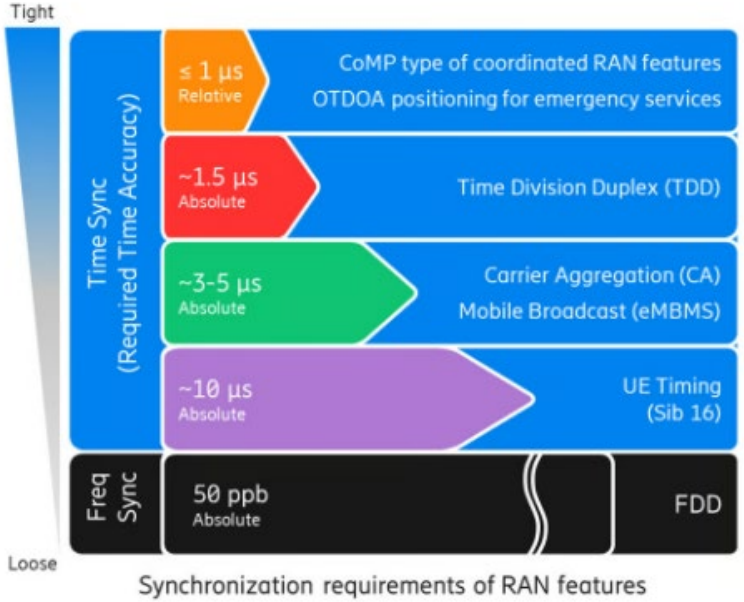
TDD

- TDD (Time Division Duplex)
  - Built to enhance bandwidth in the time domain for Uplink and Downlink
  - Real time dynamic allocation
  - **Requires precise timing**
    - Uses Time Sync Variable to measure accuracy



5G determinism

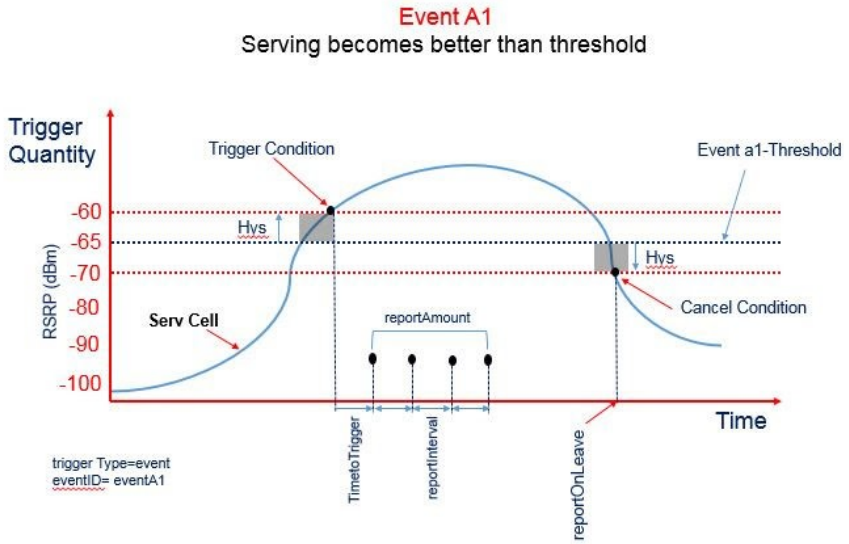
- Time Sync Variable
  - At least 1.5 us accuracy
  - Most hardware can accomplish lower rates (Coordinated Multipoint, CoMP access)
  - Eliminates complexity, completely congruent with CIP Motion Time Synchronization



Synchronization requirements of RAN features

Other Options

- Use of TEI (Time Event Identifier)
  - Used in TDD framework
    - Triggers events in TDD
    - Uses PTP message types
  - Accuracy may be dependent on hardware (More so than time Sync)
  - Event Change



Other Options

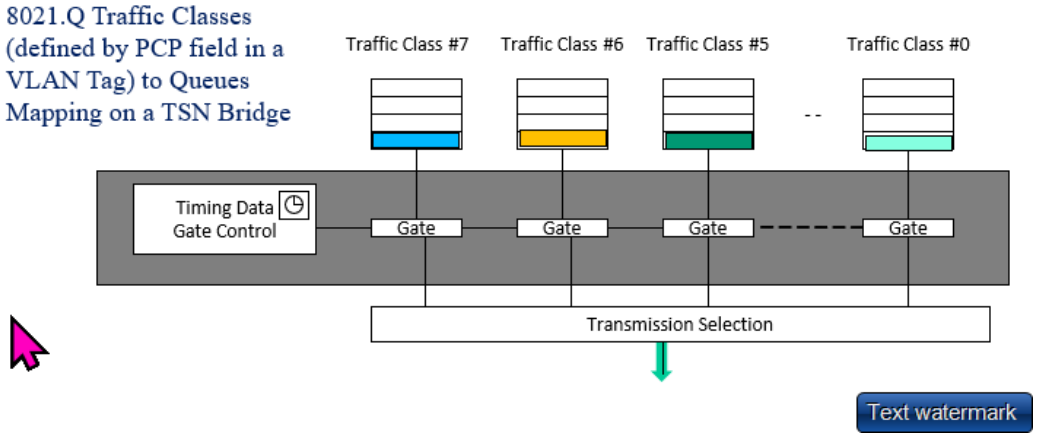
- Ethernet PDU (Protocol Data frames)
  - Easy abstraction layer for Ethernet thru 5G
    - Virtual Ethernet Cable
  - Requires use TSN Time Aware Scheduler
    - Complex
      - use of QoS configurations
      - Head-of-line Blocking configurations
        - » Conflicts with 5G Head-of-Line blocking
      - Frame pre-emption definition
      - Failover mechanism definition
    - CIP Motion solutions would not need QoS configurations, by Time Aware Scheduler is an added step

Time Aware Scheduler

- Time Aware Scheduler
  - Frame Classification
    - Quality of Service similar prioritization
  - Gate Operation
    - Open or close based

    On control
  - Guard Bands
    - Mission critical

    Exempt from gates, QoS

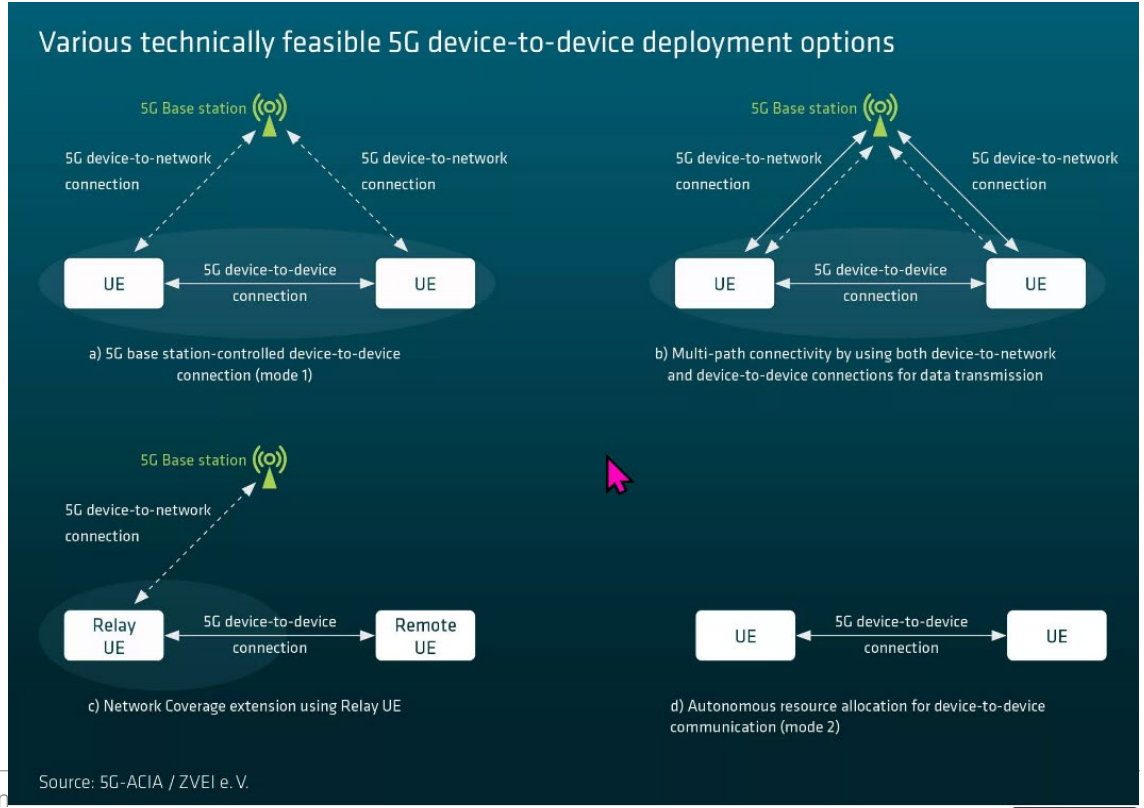


Other Options

- Sidelink
  - Device to Device communications integration
  - CIP Motion supports multi-cast peer to peer
    - Position and Velocity synchronization
  - No sync variable based on 1588, defined via Global Navigation System (GNSS) or User Equipment (Ues)

CIP Motion with 5G Sidelink

- position and velocity synchronization



Suggestions

Advantages

- Used in the 3.5 GHz range, giving maximum distance
- Easy to use/test.

Disadvantages

- Smaller cell requirement to ensure no Uplink or downlink overlap, how many cells could/should be used. Needs to be tested.
- Advanced algorithmic allocation may not work for all applications, and changing or diagnosing could be difficult. Not many industrial wireless solutions available, nor is knowledge very widespread.
- Hardware time stamping is not required on release 17 5G solutions; therefore, this needs to be checked.

Possible Applications

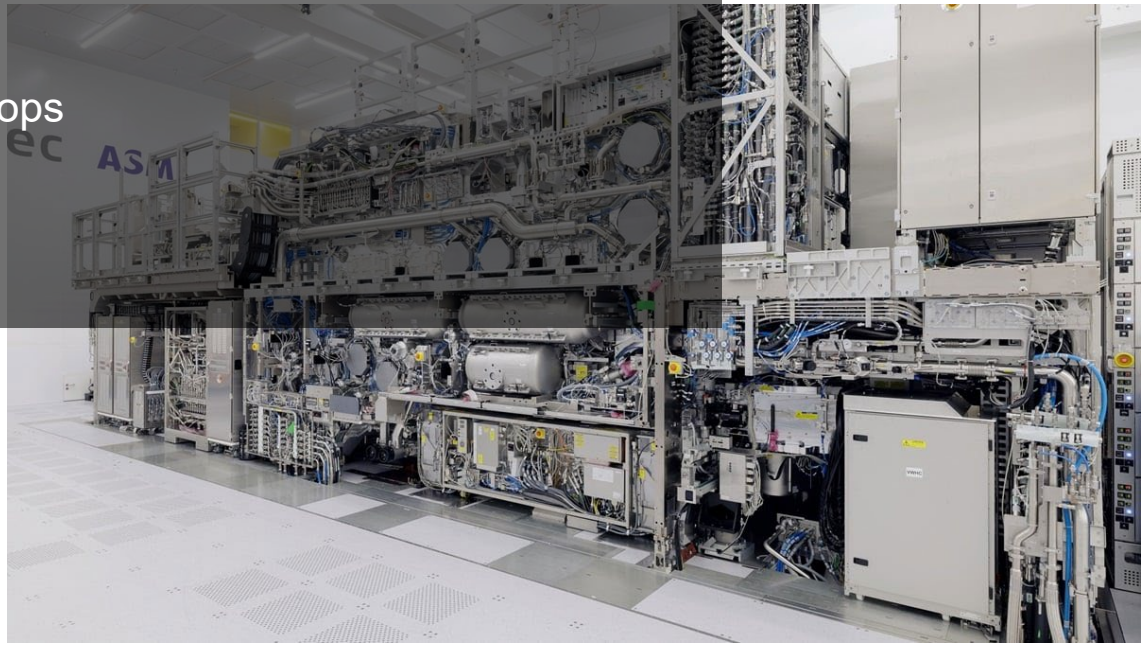
- Intralogistics
  - Automated Storage and Retrieval Systems (ASRS) systems
- Semiconductor
  - Synchronicity between cells
- Aerospace
  - Automated precision welding/adhesion

ASRS

- Intralogistics
  - Automated Storage and Retrieval Systems (ASRS) systems
  - Dense, vertical network
  - Speed is more and more important
  - Output is important

Semiconductor

- Semiconductor
  - Cell to Cell syncronization
  - Cloud enabled feedback loops



Aerospace

- Aerospace
  - On plane automated fabrication
  - Synchronization on multiple sides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YEARS!
2025
ODVA
Industry Conference and 23rd Annual Meeting