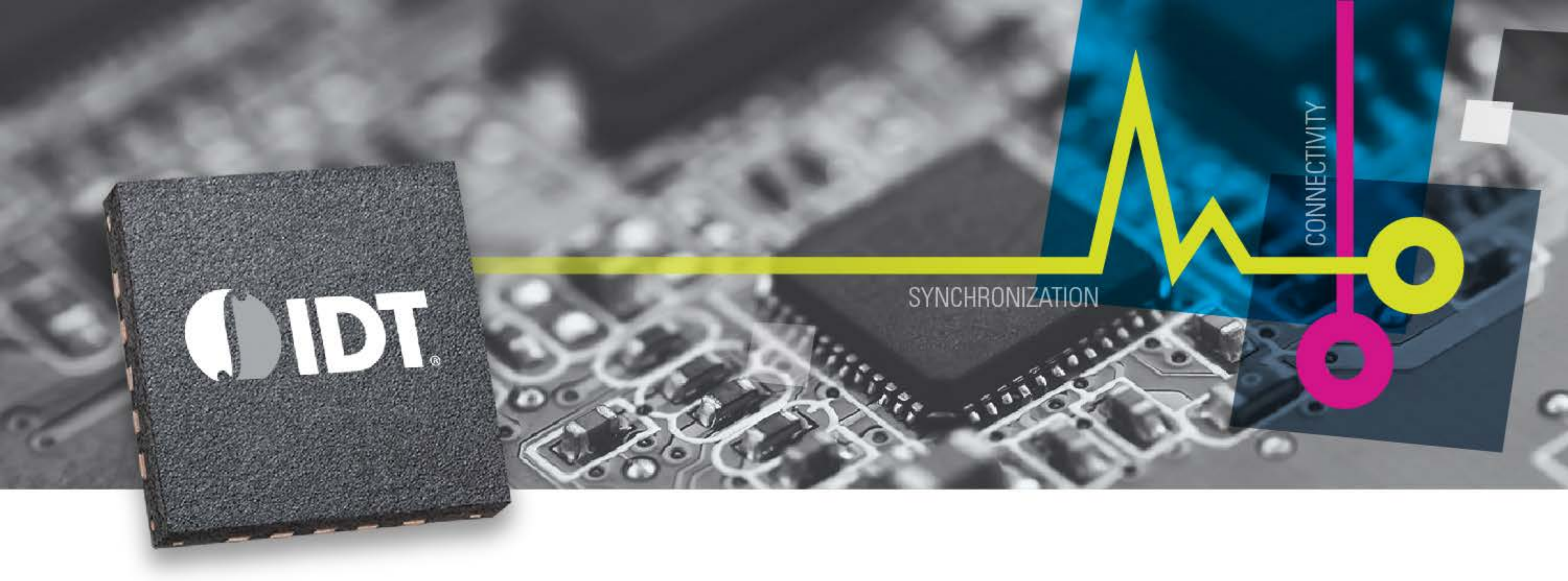


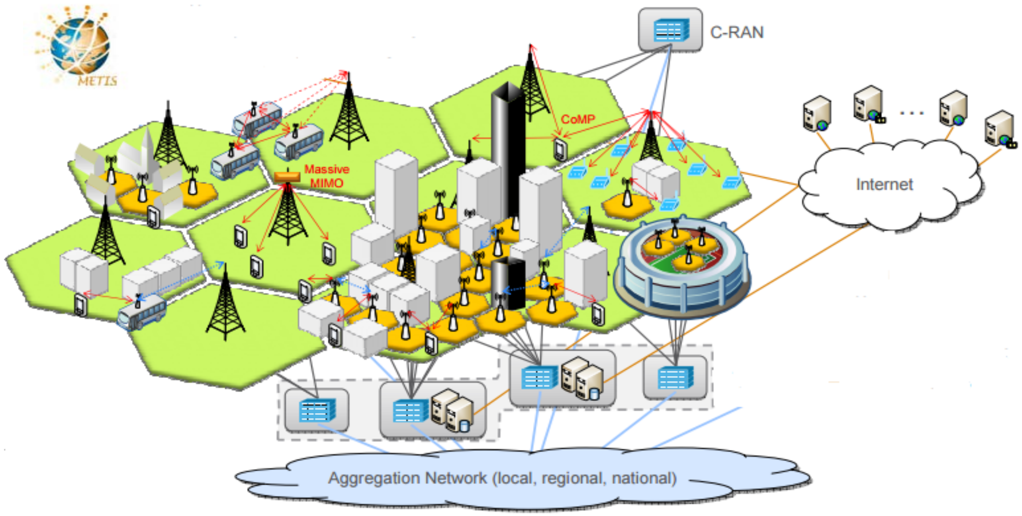
Why Synchronization Is Important to 5G

Greg Armstrong

Principal System Architect - Precision Time Synchronization

June 19, 2018

Introduction



Source: The METIS 5G Architecture: A Summary of METIS Work on 5G Architectures

- With the deployment of 5G on the horizon, several key technologies need to be in place including synchronization
- Synchronization is perceived as a key enabler for 5G, as well as a fundamental component of the new Radio Access Technologies
  - Existing synchronization solutions will need to be complemented and made more robust to meet the new demands
  - Applying to SON (**S**elf-**O**rganizing **N**etwork), SDN (**S**oftware-**D**efined **N**etworking) and NFV (**N**etwork **F**unction **V**irtualization) principles
- Synchronization needs in emerging areas, such as Cable Access, Automotive, Industrial Automation, Video Broadcast, Network Analytics, Smart Grid, etc.
- New software APIs (**A**pplication **P**rogramming **I**nterfaces) for synchronizing IoT (**I**nternet **o**f **T**hings)

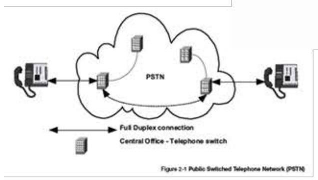
IDT

Evolution of Network Synchronization

- Synchronization has been a fundamental prerequisite for any telecommunications network
- The evolution to 5G is presenting new challenges, with an increased need of accuracy and reliability in distributing synchronization references throughout the network
  - e.g. There is an increased interest to provide terrestrial back up to Global Navigation Satellite Systems (GNSS)

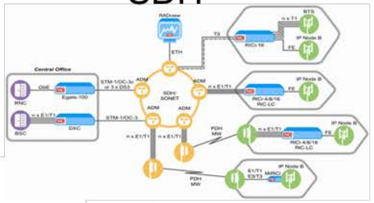
PSTN – Public Switched Telephone Network
SONET – Synchronous Optical NETwork
PSN – Packet Switched Network
IoT – Internet of Things

PSTN



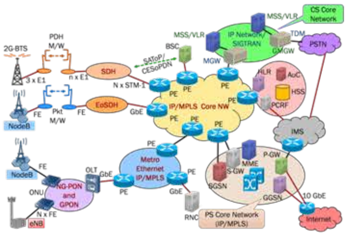
Transition from circuit-switching to synchronous protocols

SONET/ SDH



Source: RAD

PSN

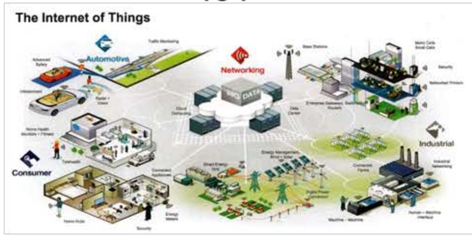


Source: LTE University

Transition to packet switching (asynchronous protocols) for bandwidth efficiency & flexibility

+ Introduce Circuit Emulation Services (CES) to support legacy circuit-switching
+ Introduce SyncE & 1588 to distribute synchronous clocks

IoT



Source: googletechinfo

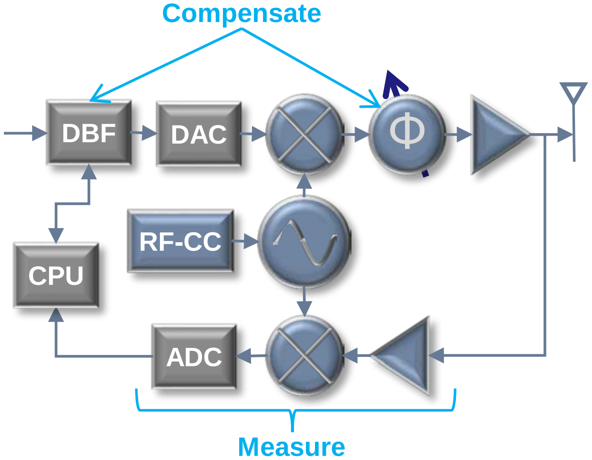
Transition to Heterogeneous Network (HetNet) for seamless user experience 'everywhere'

+ Expand 1588 deployments to distribute synchronous time clocks

Requirements for 5G Radio Access

- For 5G Radio Access Technologies, the disaggregated basestation components will need to be coordinated in time as though they were in one box
- This is driving new synchronization requirements for the front-haul network between the Base Band Unit (BBU) and the Remote Radio Head (RRH)
- Within the RRH itself, advanced techniques such as multiple input, multiple output (MIMO), Cooperative Multi-Point (CoMP), Further enhanced Inter-Cell Interference Coordination (FeICIC), and beam forming will require very tight synchronization

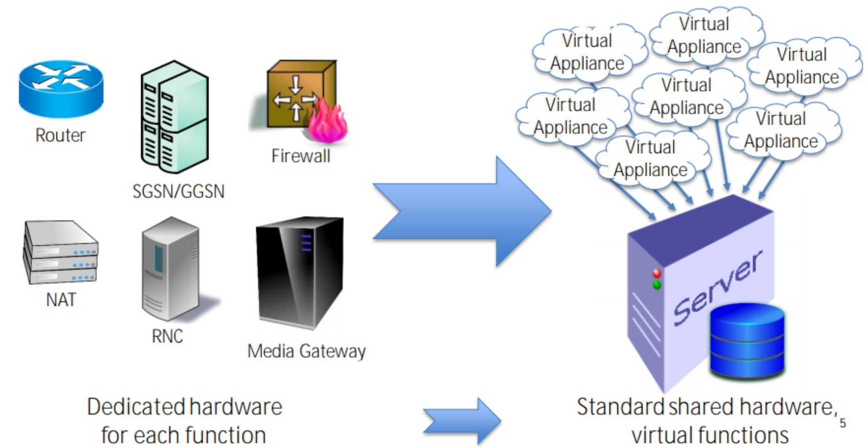
Application Example: Remote Radio Head (RRH)



- Massive MIMO uses many (64+) radio paths to form beams
  - Narrow beams need tightly controlled phase
  - Difference in delay from one antenna to another (asymmetry) matters
- Path asymmetries in radio & timing paths are measured & compensated
  - Measured through receive path (TDD) or DPD path (FDD)
  - Compensation added where beam-forming is done, in digital or analog
- Initial calibration cycle will cover all fixed delays in the path
  - Absolute value of delay in each path is factored out
  - Subsequent periodic calibrations detect variations due to voltage or temperature
- The more stable the variation in phase through a device, the less frequent the calibration cycles need to be
  - Goal for all components is therefore stability in phase delay, not minimal phase delay
  - Have heard goal 1psec of phase variation per 1degC temp change at antenna

Addressing SON, SDN and NFV Principles

- SON allows node-based network discovery
  - Proliferation of radios puts pressure on RRH costs (capital, operating & installation expenses)
- SDN allows networks to handle many different services dynamically
  - Driven by the increasingly complex means to manage large IP/ETH networks and sharing of cloud data centres
- NFV allows the virtualization of network functions using 'generic' servers
  - Carrier-driven to reduce costs for services
- Both of these principles are driving the need to bring synchronization into the 'virtualized' network



5

Source: Sync in a NFV World, WSTS 2016 (Calnex)

Sync Standards Related to 5G

- Various standardization bodies, such as the ITU-T, are evolving existing standards or introducing new ones to prepare the road for 5G
  - Synchronization over packet
    - G.8271, G.8271.1, G.8273.2, G.8275.1 (T-BC, T-TC & T-TSC)

      * T-BC Class C being discussed at ITU-T
    - [evolving] G.8262.1 (eEEC)
    - [evolving*] G.8271.2, G.8273.4, G.8275.2 (T-BC-P & T-TSC-P)

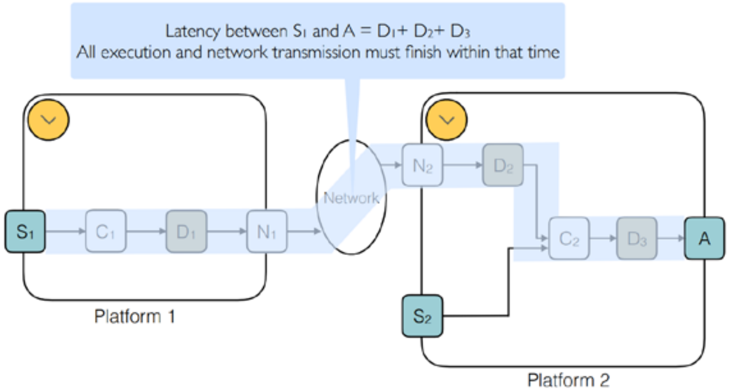
      * Can be looked at as evolving from G.8261, G.8263 (PEC-S-F), G.8265.1 (SOOC)
  - Reconstruct clocks from RoE and CPRI over Ethernet
    - [new] IEEE 802.1CM (Time-Sensitive Networking for Fronthaul)
    - eCPRI Specification v1.0
  - GNSS backup
    - [new] G.8273.4, G.8275.2 (Assisted Partial Time Support (APTS) clocks, or T-TSC-A)

Needs in Emerging Areas

- A lot of emerging areas are also looking at synchronization
  - Intelligent Transport Systems
  - Industrial Automation
  - Network Analytics
  - Smart Grid
  - Cable Networks
  - Autonomous Vehicles
  - etc.

APIs for IoT

- IoT specific aspects are driving the need of synchronization, creating new software APIs
  - If this happened (and at this time), then …
- How do we get time into software
  - Challenges in programming with "Time"
  - e.g. It should take exactly 100ms between sensing x and actuating y, with an acceptable tolerance of 2ms



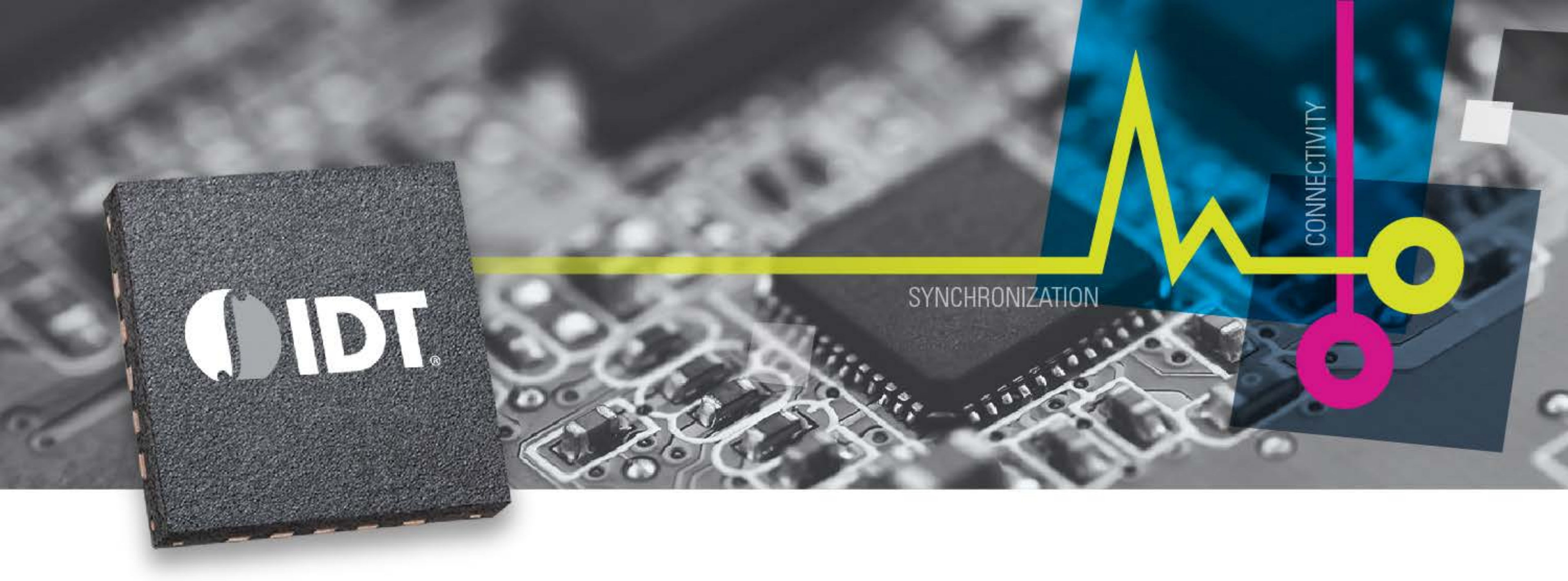
Source: Programming with Time, WSTS 2017 (Patricia Derler, National Instruments)

- To build complex applications, we need the right levels of abstraction
  - Instead of abstracting away time, we should provide the right API to program with time

Summary

- Synchronization will continue to be important for 5G
- Some aspects include (but are not limited to):
  - evolving existing and introducing new synchronization standards
  - the front-haul synchronization requirements for the new 5G radio access;
  - the application of SDN and NFV principles to the network synchronization; and
  - the synchronization needs in emerging areas;
  - IoT specific aspects such as the definition of APIs.

IDT



Thank You

Analog Mixed Signal Product
Leadership in Growth Markets