OCN Taxonomy and Reference Model

Side Meeting on Operations and Control Networks

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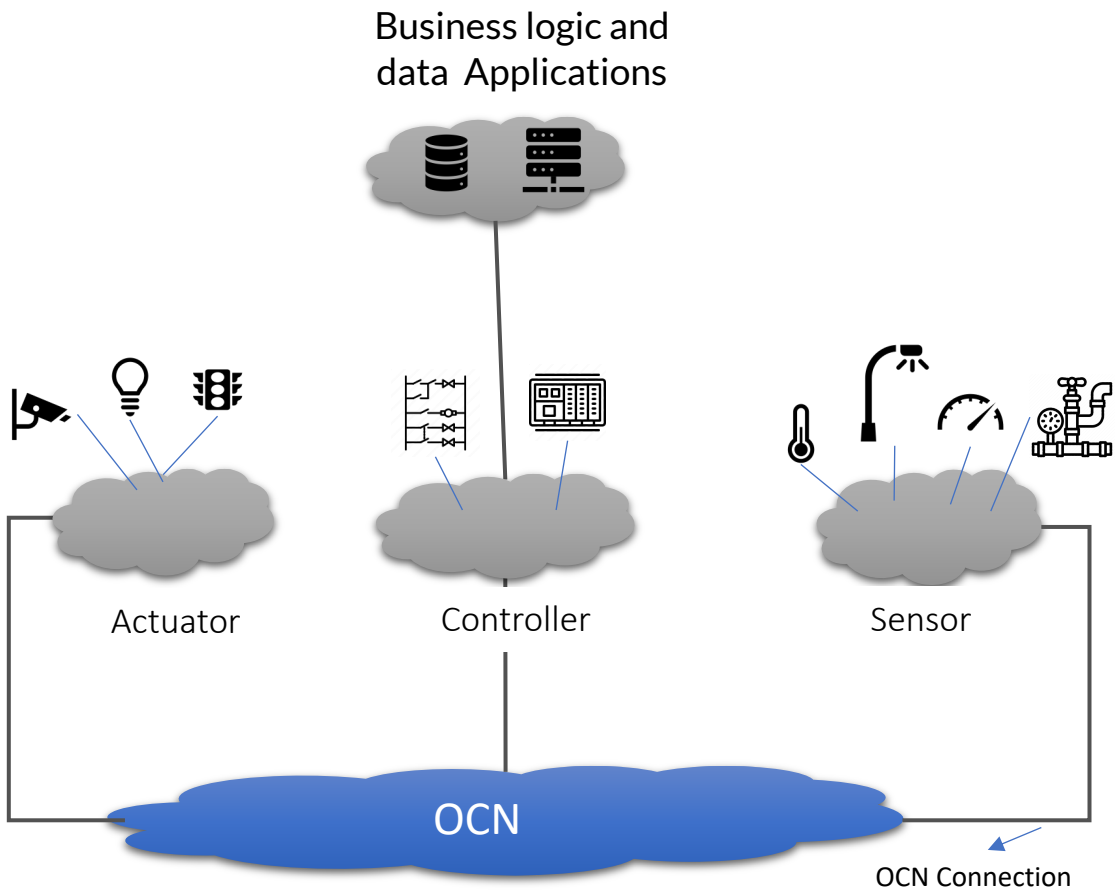
What is OCN?

We generalize a network for control systems based on two aspects

1. That the field devices do not operate on their own.
    - Instructed by controllers to do certain actions and read certain sensory data.
    - Those controllers can be of any form-factor (small, large, lots of processing power, etc.)
2. For a given application the behavior and operations are well-defined.
    - Characteristics of sensors are quite specific. Emitting data towards controller.
    - Actuator properties – Write and readback type of commands.

Motivation

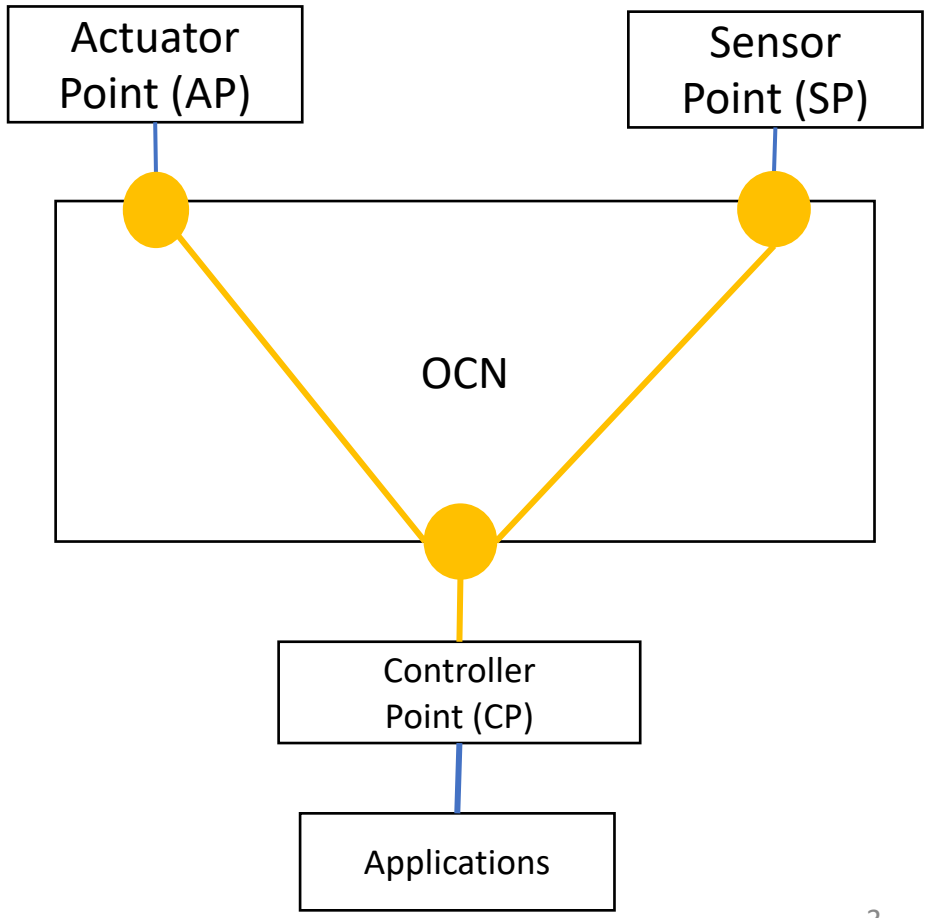
- There are growing number of “remote operation” type of use cases in which there’s network between field devices and the controller.



OCN Reference Model

We can start by thinking of OCN as an abstraction of control systems.

- With key logical role-based Reference points
    - Actuators
    - Sensors
    - Controller
- Then standardize
    (a) interfaces and
    (b) common message types and
    (c) corresponding network-constraints

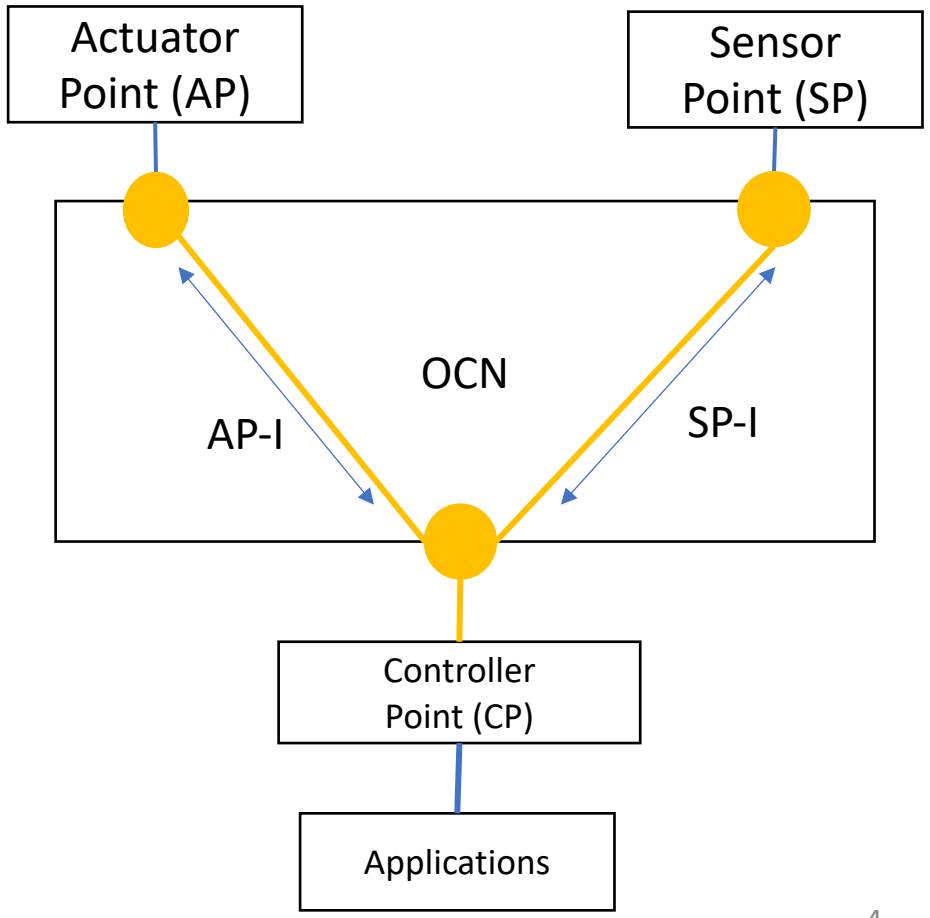


OCN Reference Model - Interfaces

Nomenclature used for Reference points

- Actuator Point (AP)
- Sensors Point (SP)

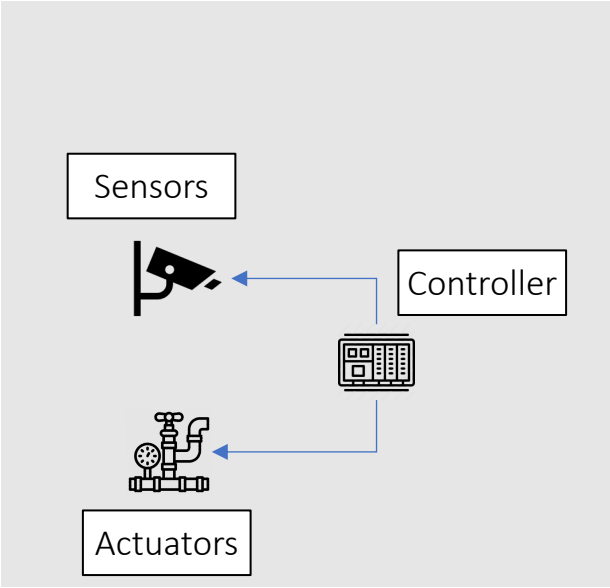
- **Sensor Point Interface (SP-I) CP ←→SP**
  - Expresses sensor type behavior.
  - Concern with data emitted by sensor
  - Message severity, periodicity, etc.
  - Solicit reads from sensors
- **Actuator Point Interface (AP-I) CP ←→AP**
  - Typical actuating point.
  - Data the brings out changes to physical environment or mechanical movements.
  - Precise time-based message delivery, feedback control loop, open control loop

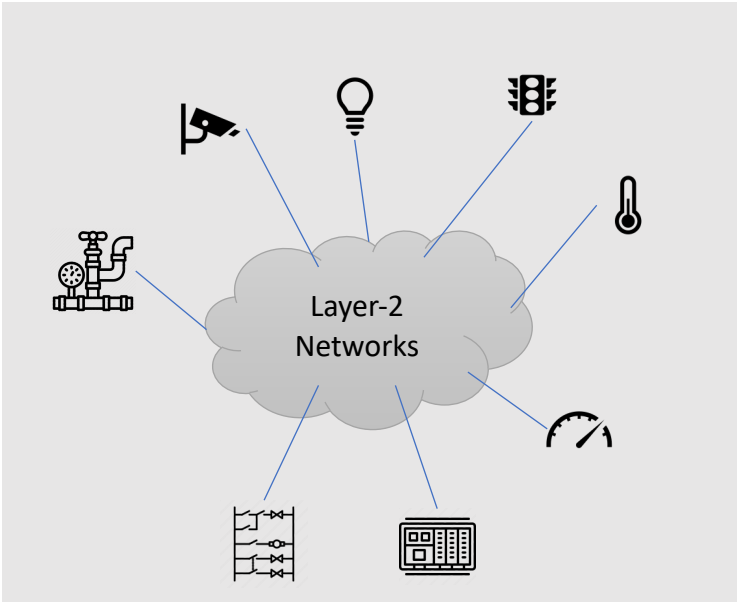


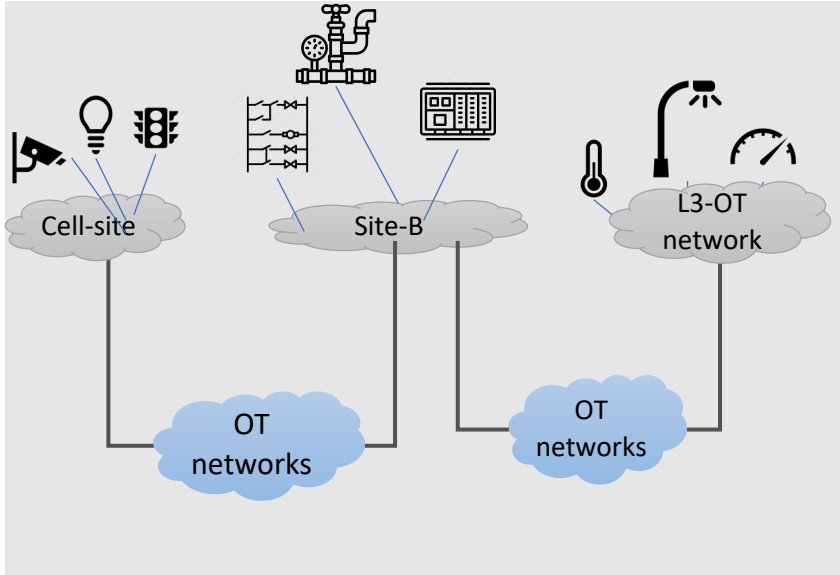
OCN Messages and network characteristics

- On-time messages
  - At the specified time.
- Bounded latency messages
  - With in a specified time interval
- Periodic messages
  - Regular telemetry data
- Order of Messages
  - because field devices do not buffer packets. Network should ensure this.
- Reliability
  - Ensure packet losses are detected and reported because each message is a command to the controller.
- Safety
  - Of operation and overall system. No late (stale) packets, no duplicate packets (operate machine twice)
- Synchronization
  - Common reference for timestamps
- Security

OCN Realizations







Layer 1 or

Direct Physical connection

- Directly meets the high-precision requests and all types of messages
- Latency/Packet loss is NOT a concern
- E.g. Modbus, Profibus, etc.

Layer 2 or

LAN connection

- Meets high-precision requests
- Support some types of messages
- Concerns on Latency/Packet loss
- Some known algorithms & methods
- E.g., Wifi, TSN, RT-Ethernet, 5G-NR, etc

Layer 3 or

WAN connection

- Barely meet high-precision requests
- No support for OCN message types
- Concerns about Latency/Packet loss
- Some mechanisms are available
- E.g., DETNET

issues

- Scalability
- Performance of operations between the reference points
- How to go about supporting messages/expressing interfaces described.