OpenCNC

A software-defined control plane for automating TSN network configuration

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Agenda

1. Introduction
2. OpenCNC design
3. TSN Network optimization
4. Conclusion
Needs/Trends:

- Collecting and Making use of billions of sensor data IoT
- Analyzing data and acting upon it in Real-time Analytics
- Autonomous Decisions guided by algorithms ML
Connected Cyber-Physical Systems □ In Future

• Characteristics and Benefits
  • In software, virtualized, programmable, upgradable, commodity infrastructure, open, interoperable, customizable, Intelligence
  • Increase flexibility, reduce deployment time and cost
**Characteristics and Benefits**

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**Introduction: AIDA - A Holistic AI-Driven Networking and Processing Framework**

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Control Plane

Edge Nodes (intelligent processing, vPLCs)

TSN Network

Edge Nodes (intelligent processing, vPLCs)

Shop floor (sensors, actuators, …)
▪ TSN: Converged Real-Time Networks
▪ Rich eco-system
  – Multiple networking technologies e.g. 5g, DetNet...
  – Multiple standardization bodies
▪ Diverse applications and solutions
  – Diverse end-systems, Virtualisation...
  – Many projects treating different parts of the TSN world e.g. AIDA
▪ Standardization advancing but gaps exist

Big potential for TSN, many pieces but no complete image
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TSN Network Control and Management plane

- CUC
- 5G systems
- Centralized Monitoring service
- Analytics / simulation / network optimization
- Edge node controller / Eng. tool
- virtualized application: vPLC
- Edge node configuration
TSN Network Control and Management plane

- OpenCNC: A software-defined control plane for automating TSN network configuration

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TSN Network Control and Management workflow

Network User

Requirements
Streams requirement
Topology / Resources

Optimization
Problem modeling
Algorithm design

Configuration
Manage configuration/
re-configuration
process

Monitoring
Read switch counter
Run diagnostics of
them

Inference from monitoring data
OpenCNC: overview

- Modular (µServices-based)
- Cloud-native (Kubernetes)
- Easy to scale up and out
- Adaptive to the needs of the network administrator
- Part of a holistic AI-driven networking and processing Framework (AIDA)

Link to OpenCNC: https://github.com/AIDA-KAU/OpenCNC
Contribution to the conference TSN/A 2022: Towards Viable Open Source TSN - From Endpoint to Network Configuration
Log data from all the microservices about all the internal processing.

Network monitoring data: all counters from all the switches in the network.

Contribution to the conference TSN/A 2023: Closing the configuration loop with OpenCNC and ControlTSN Frameworks.
get_streams: returns all configured streams

get_talkers: returns all registered talkers

get_listeners: returns all registered listeners

Contribution to the conference TSN/A 2023: Closing the configuration loop with OpenCNC and ControlTSN Frameworks
Network optimization interface

Optimize the network configuration
Check the quality of the schedule
Simulate the network

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Contribution to the conference TSN/A 2023: Closing the configuration loop with OpenCNC and ControlTSN Frameworks
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Network optimization interface

capabilities: {sched: "this algo does...", sched/route: "this algo does...", sched/route/embed: "this algo does..."}
Inputs: {JSON_UC: expFile, CSV_plain: expFile}
Outputs: {JSON_FINISHED_UC: expFile}

External optimizers:
- optimizer_ip: 192.168.0.1
  optimizer_name: reconfg_GA
  port: 5555
  description: "this algorithm does..."
  capabilities: [sched, sched/route, sched/route/embed]
  input: JSON_UC
  output: JSON_FINISHED_UC
  max_response_time[s]: 300
  sync: True
- optimizer_ip: 192.168.0.2
  optimizer_name: conf_RL
  port: 5555
  description: "this algorithm does..."
  capabilities: [sched]
  input: JSON_UC
  output: JSON_FINISHED_UC
  max_response_time[s]: 1500
  sync: False

Optimization process:
- optimize(input, option=sched)
- result if sync=True
  or
  plan_ID if sync=False
- get_result(plan_ID)
- result
Network Optimization

- No overlap
- No looping
- minimum jitter
- stream sequencing
- Respect QoS requirements e.g. latency
- Flow conservation
- Traffic is cyclic

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Network Optimization

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Problem extensions

Network Configuration extended to:
- Task placement
- Routing
- Scheduling
Techniques

ILP formulation + of-the-shelf solve

AI: reinforcement learning

Heuristics e.g. Genetic algorithms
Techniques

ILP formulation + of-the-shelf solvers

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Under submission: “Optimizing TSN Routing, Scheduling, and Task Placement in Virtualized Edge-Compute Platforms”
Questions?