Modeling of a railroad worker protection system architecture in PFS

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- Controls Automation Engineer;
- Studying master's at University of São Paulo focusing on the automation area;
- 7 Years of experience on automation projects, more specifically SCADA systems.
  - 5 Years with the metro system;
    - São Paulo metro lines: line 5, line 4, and line 15
  - 2 Years with the subsea system for the oil&gas industry.

Agenda

- Introduction
  - Objective
- Related work
- State of art
  - Metro system;
  - Production Flow Schema (PFS).
- Architectures modeling
  - Metro system architecture;
  - Railroad worker protection system architecture.
- Conclusion

Introduction

- Metro system is the most efficient option to be implemented in urban areas [1];
- Metro system in
  - London (1890);
  - Chicago (1897);
  - São Paulo (1974).
- Legacy system
  - Old systems that cannot be easily stopped;
  - Demand frequent and complex maintenance.

Introduction

#	Location	Accident	Railroad worker protection available	Ref.
1	São Paulo (Brazil)	Run over by a train	30-Years of experience Personal Protection Equipment (PPE)	[6]
2	São Paulo (Brazil)	Electrocuted	PPE Aware of the safety rules	[7]
3	New York (USA)	Run over by a train	5-Years of experience Lights and signals to avoid any accident	[8]
4	London (UK)	Run over by a train	System to send an alarm to the railroad worker when a train is close	[9]

Objective

Railway switch energized

Power rail energized

Train running

Fire detector activated

Present a railroad worker protection system architecture

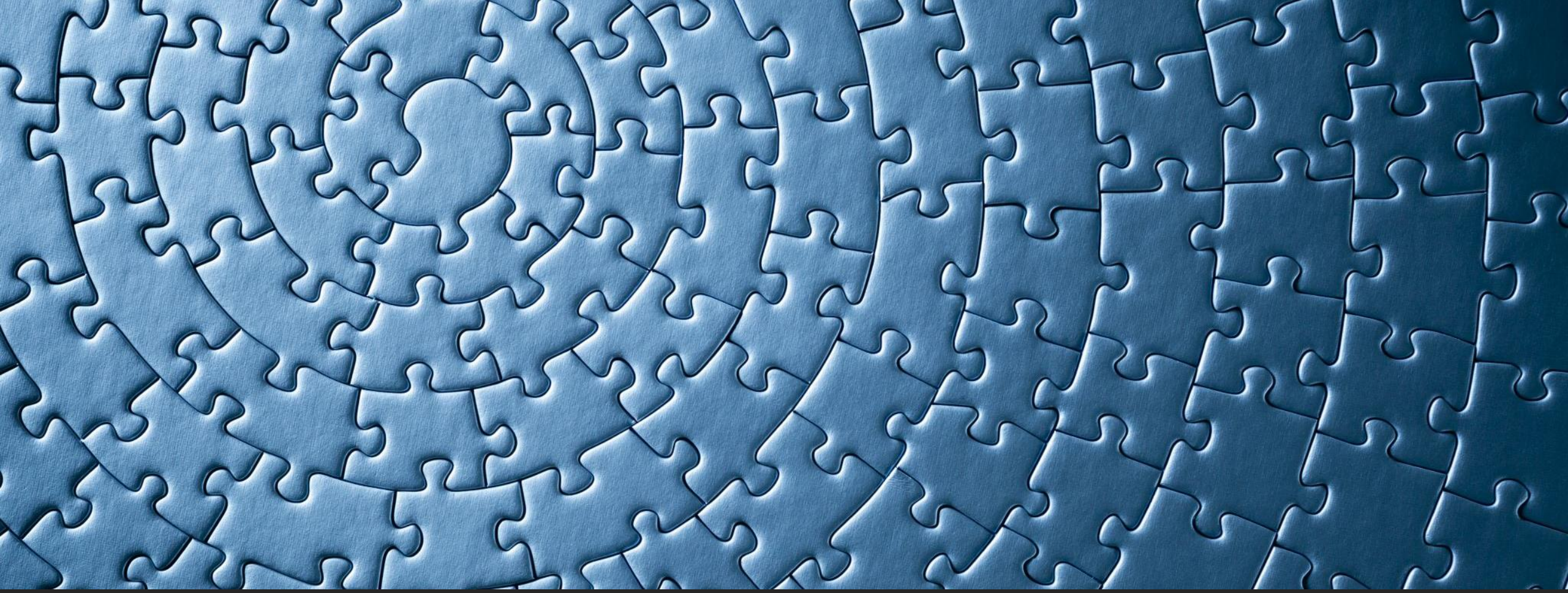
- Automatic protection
- Automatic update to the operator (OCC) and railroad worker
- Integrate with the metro system with minimum interference
- Simplify operator work at OCC*
- Modeled in PFS

*OCC= Operation Control Center

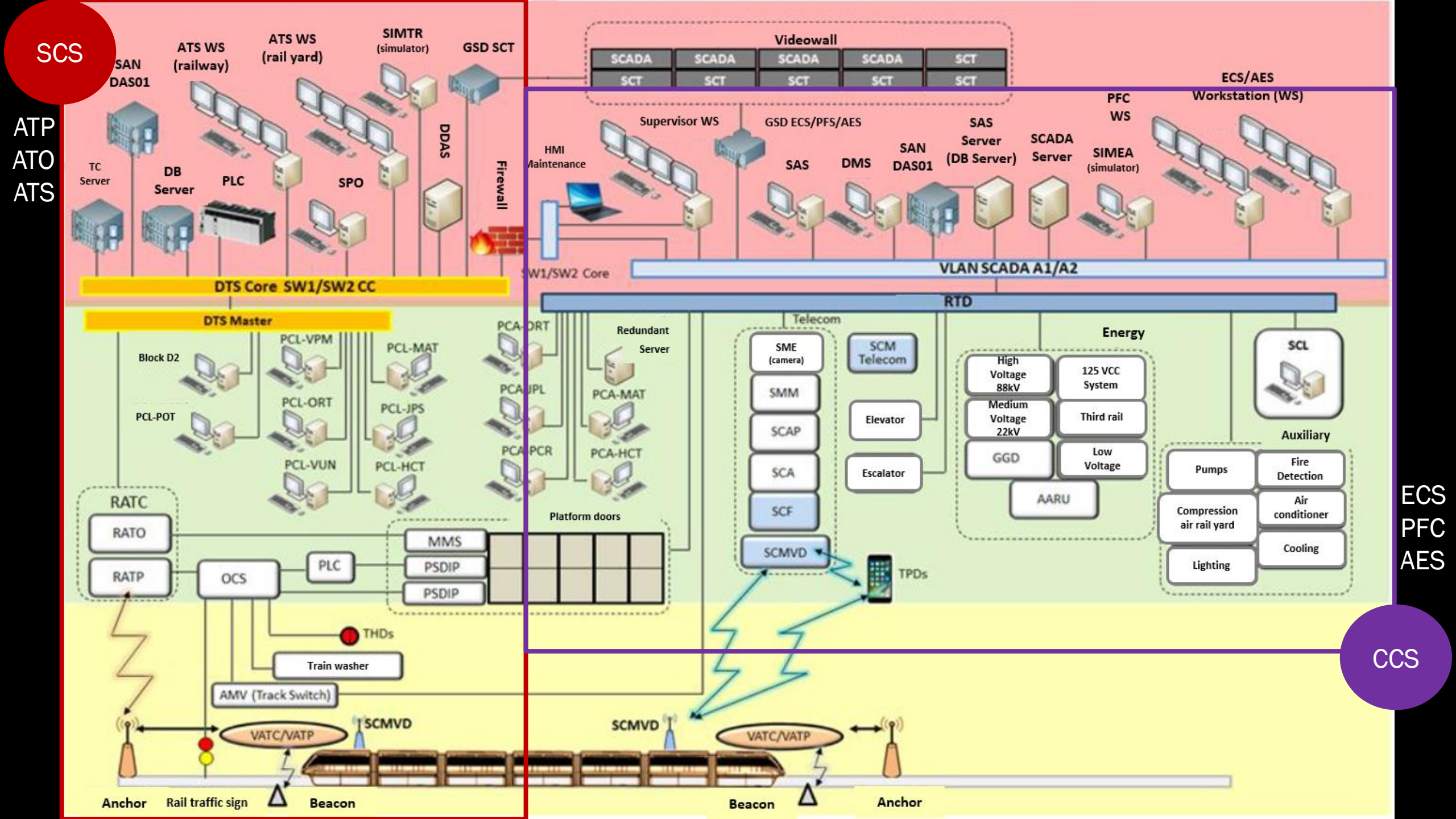
Related work

Related Work

- Fiber optic portable rail vehicle detector [11];
- Enhancing workers safety in worksites through augmented GNSS sensors [12];
- Construction Worker Tracking and Safety: Paris Subway (Litum) [13];
- Safety mechanism to verify damage on track segment to prevent derailing [14];
- Wearable computing for railway environments: proposal and evaluation of a safety solution [15].

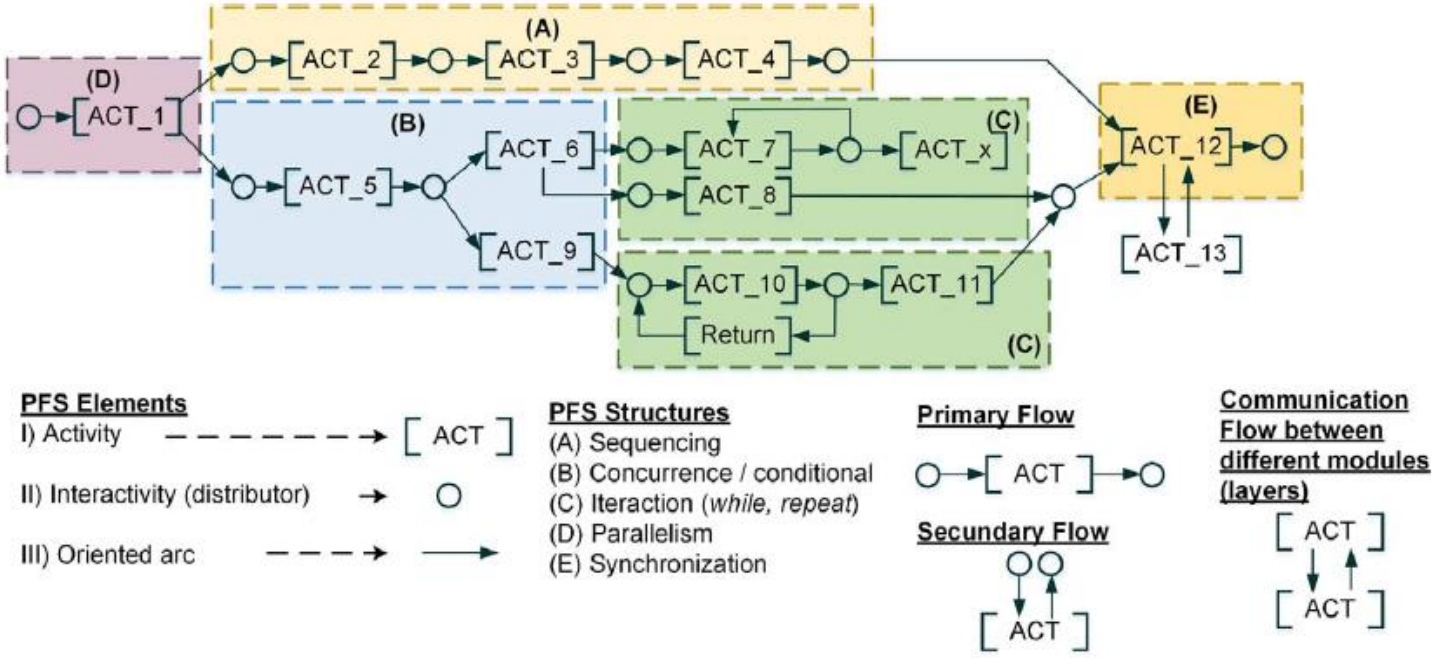


State of art


SCS
ATP
ATO
ATS
SAN DAS01
ATS WS (railway)
ATS WS (rail yard)
SIMTR (simulator)
GSD SCT
DDAS
Firewall
TC Server
DB Server
PLC
SPO
DTS Core SW1/SW2 CC
DTS Master
Block D2
PCL-VPM
PCL-MAT
PCL-POT
PCL-ORT
PCL-JPS
PCL-VUN
PCL-HCT
RATC
RATO
RATP
OCS
PLC
MMS
PSDIP
PSDIP
THDs
Train washer
AMV (Track Switch)
VATC/VATP
SCMVD
Anchor
Rail traffic sign
Beacon
Videowall
SCADA
SCT
Supervisor WS
GSD ECS/PFS/AES
HMI Maintenance
SAS
DMS
SAN DAS01
SAS Server (DB Server)
SCADA Server
PFC WS
SIMEA (simulator)
ECS/AES Workstation (WS)
SW1/SW2 Core
VLAN SCADA A1/A2
RTD
Redundant Server
PCA-MAT
PCA-HCT
Platform doors
Telecom
SME (camera)
SMM
SCAP
SCA
SCF
SCMVD
SCM Telecom
Elevator
Escalator
TPDs
Energy
High Voltage 88kV
125 VCC System
Medium Voltage 22kV
Third rail
GGD
Low Voltage
AARU
SCL
Auxiliary
Pumps
Fire Detection
Compression air rail yard
Air conditioner
Lighting
Cooling
SCMVD
VATC/VATP
Beacon
Anchor
ECS
PFC
AES
CCS

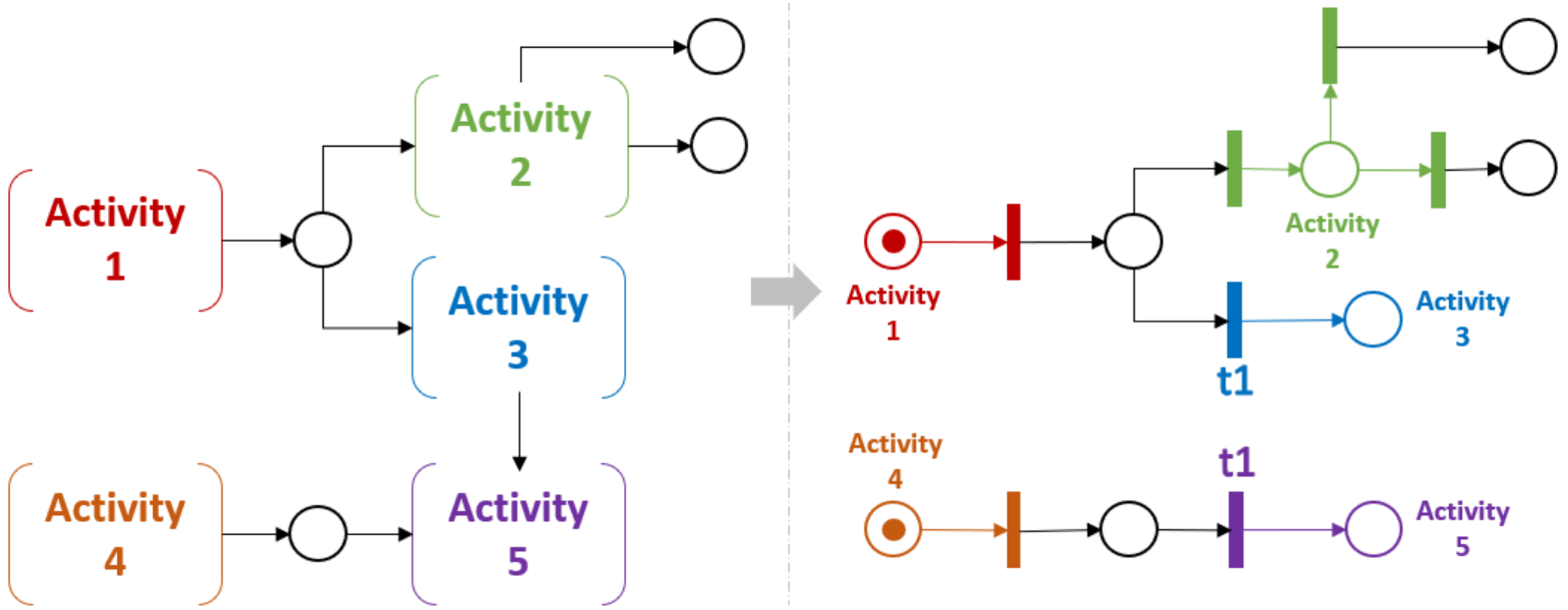
Production Flow Schema (PFS)

- Interpreted graph from Petri Net (PN);
- Systematize and facilitate the system modeling process;
- Allows exploring macro events;
- Does not have a token;
- Compound of:
  - Activities;
  - Distributors;
  - Oriented arcs.

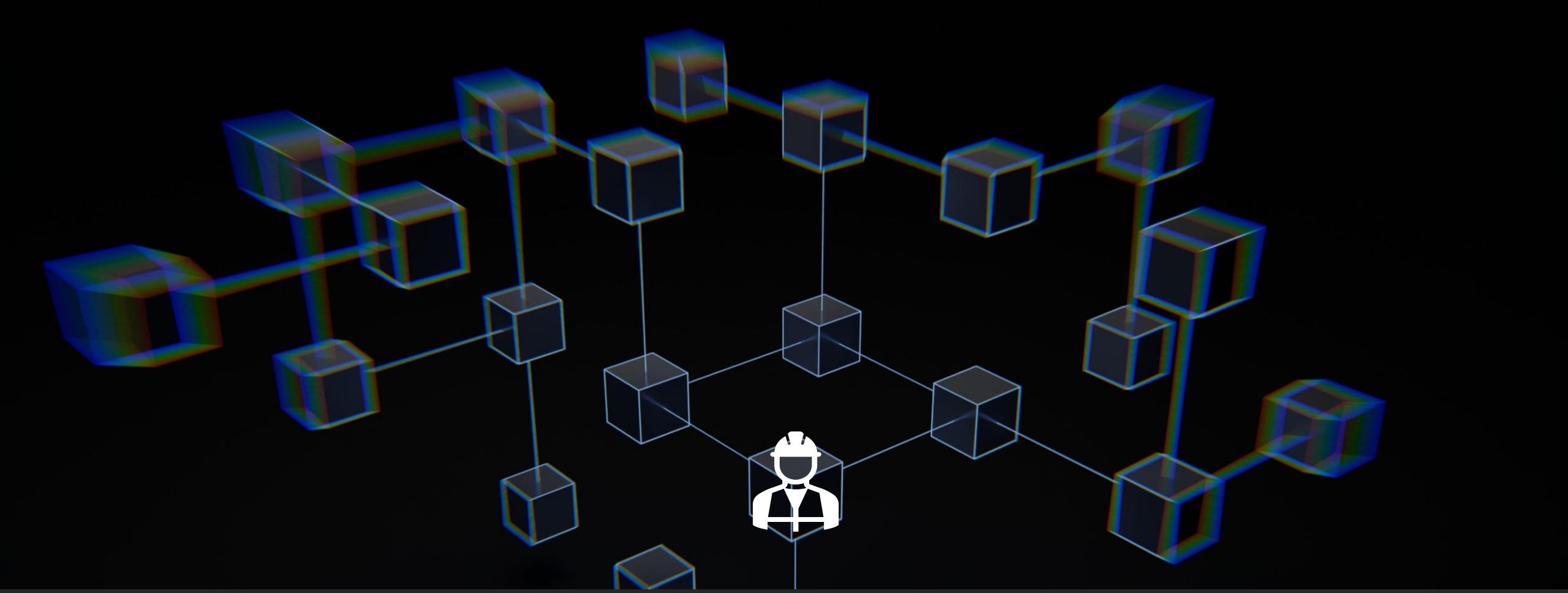


Production Flow Schema (PFS)

- Inherited PN properties:
  - EN 50128 – software development requirement for railway applications [23];
  - Safety properties [24].
- Conversion to PN or CPN*.

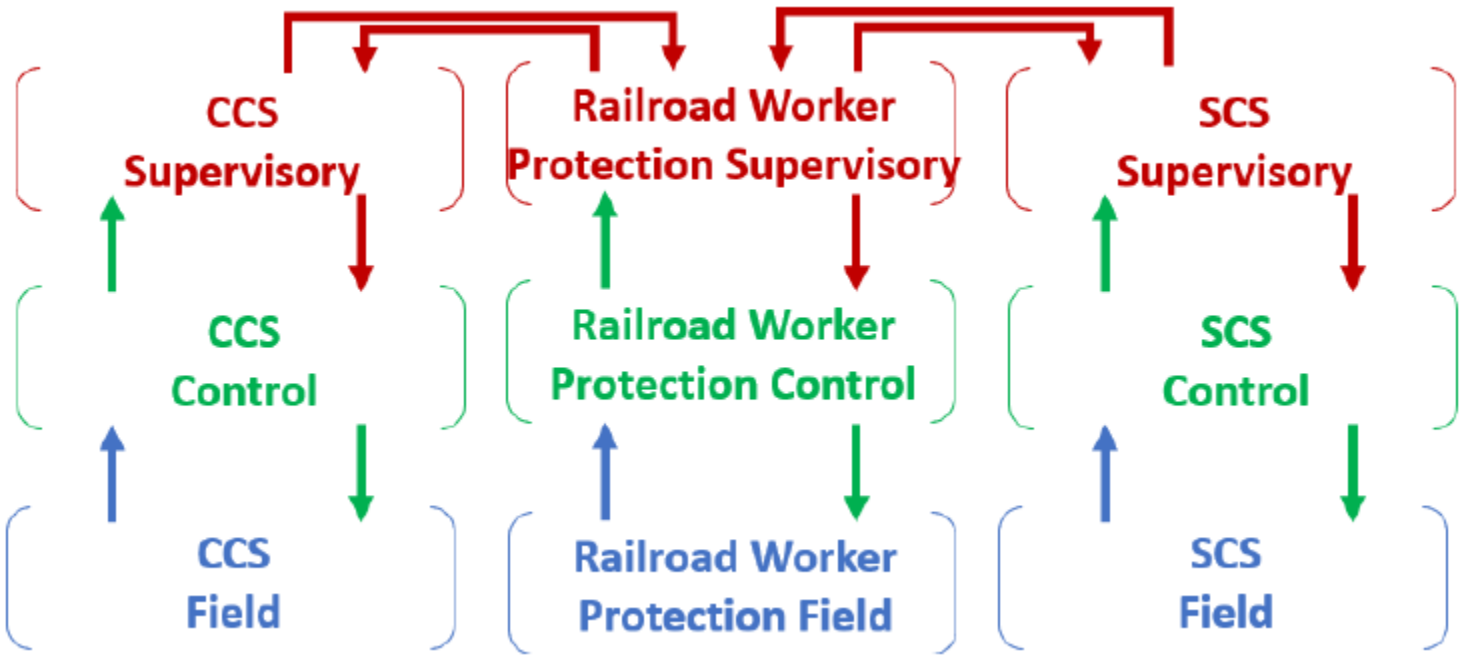


*CPN: Coloured Petri Net

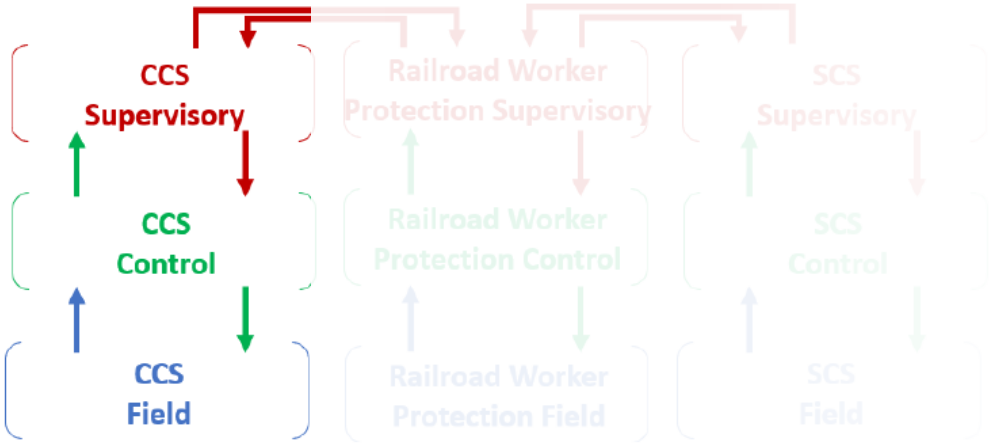


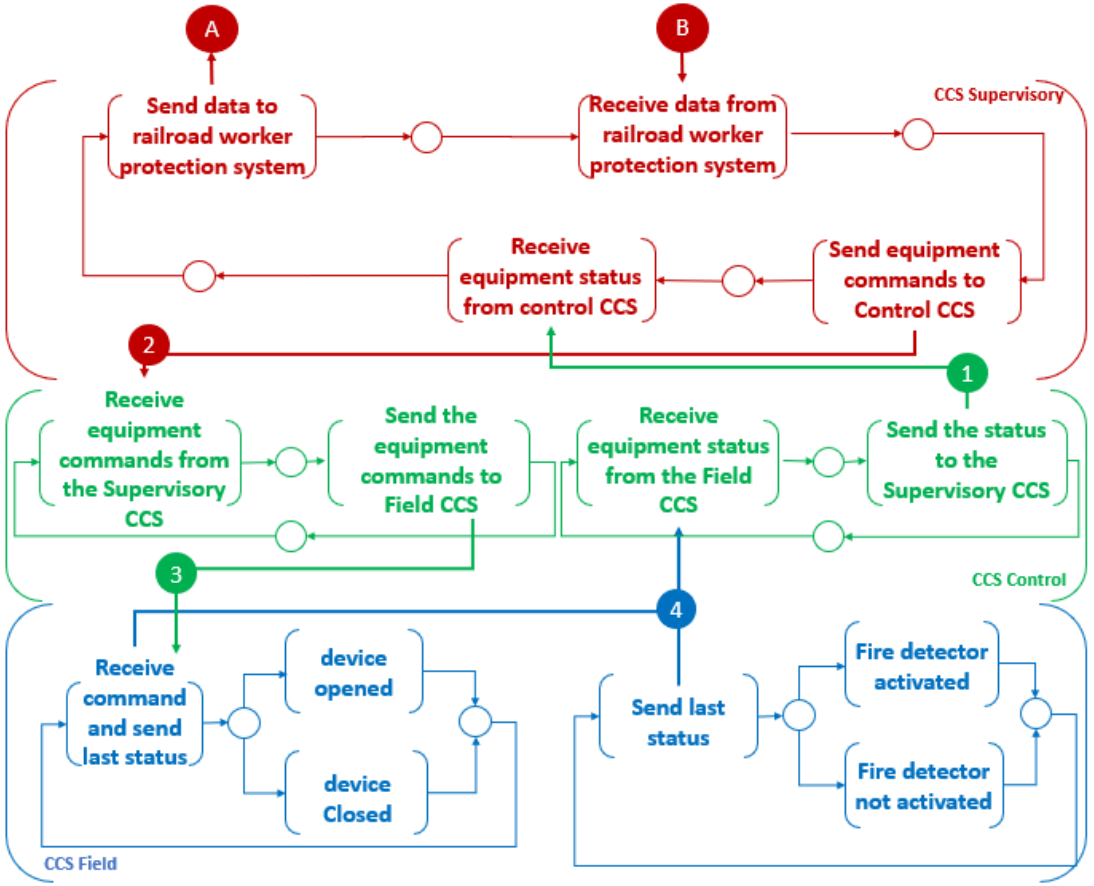
Architecture modeling

Overview of the architectures

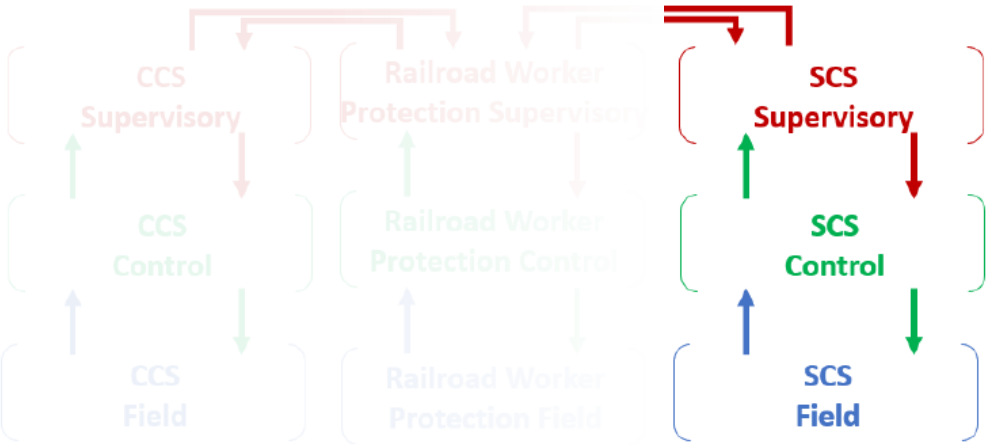


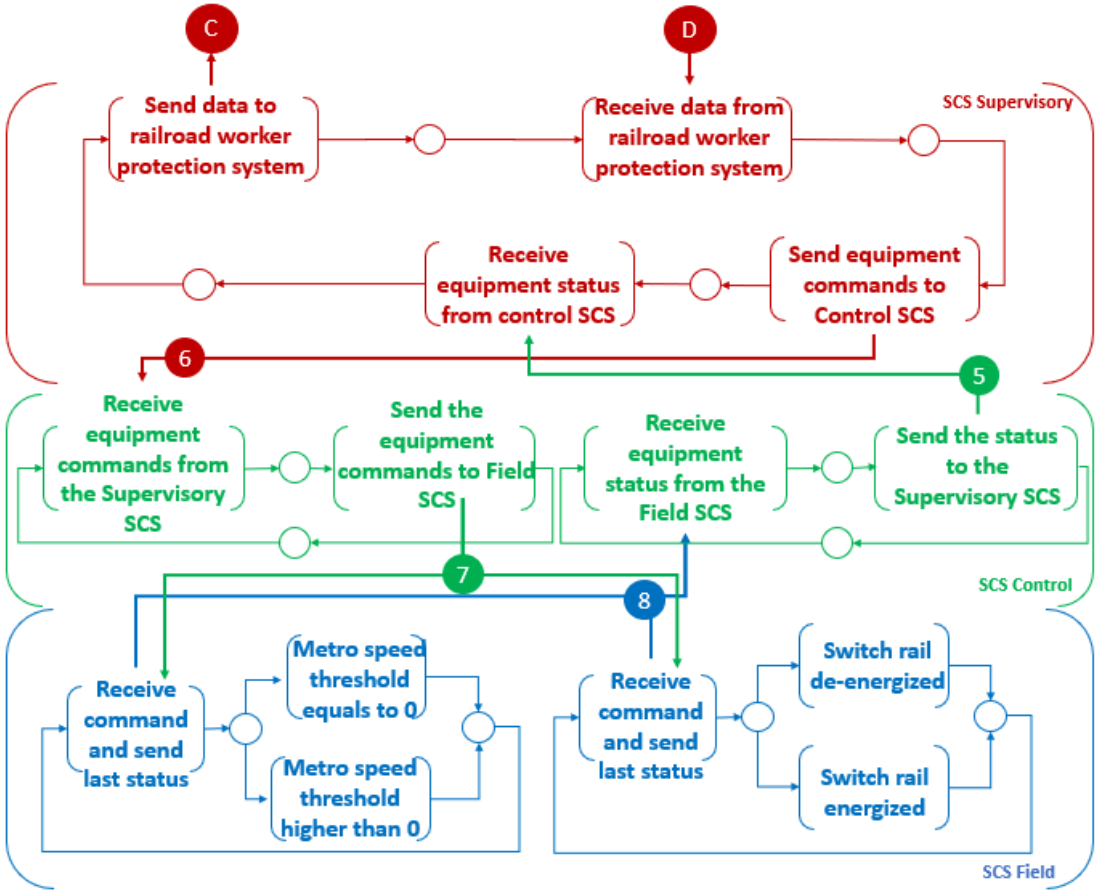
Metro system architecture: CCS model



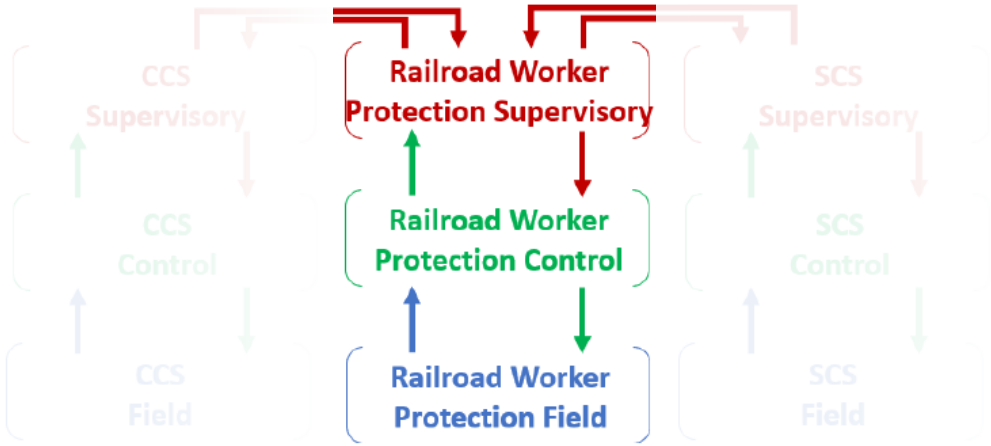


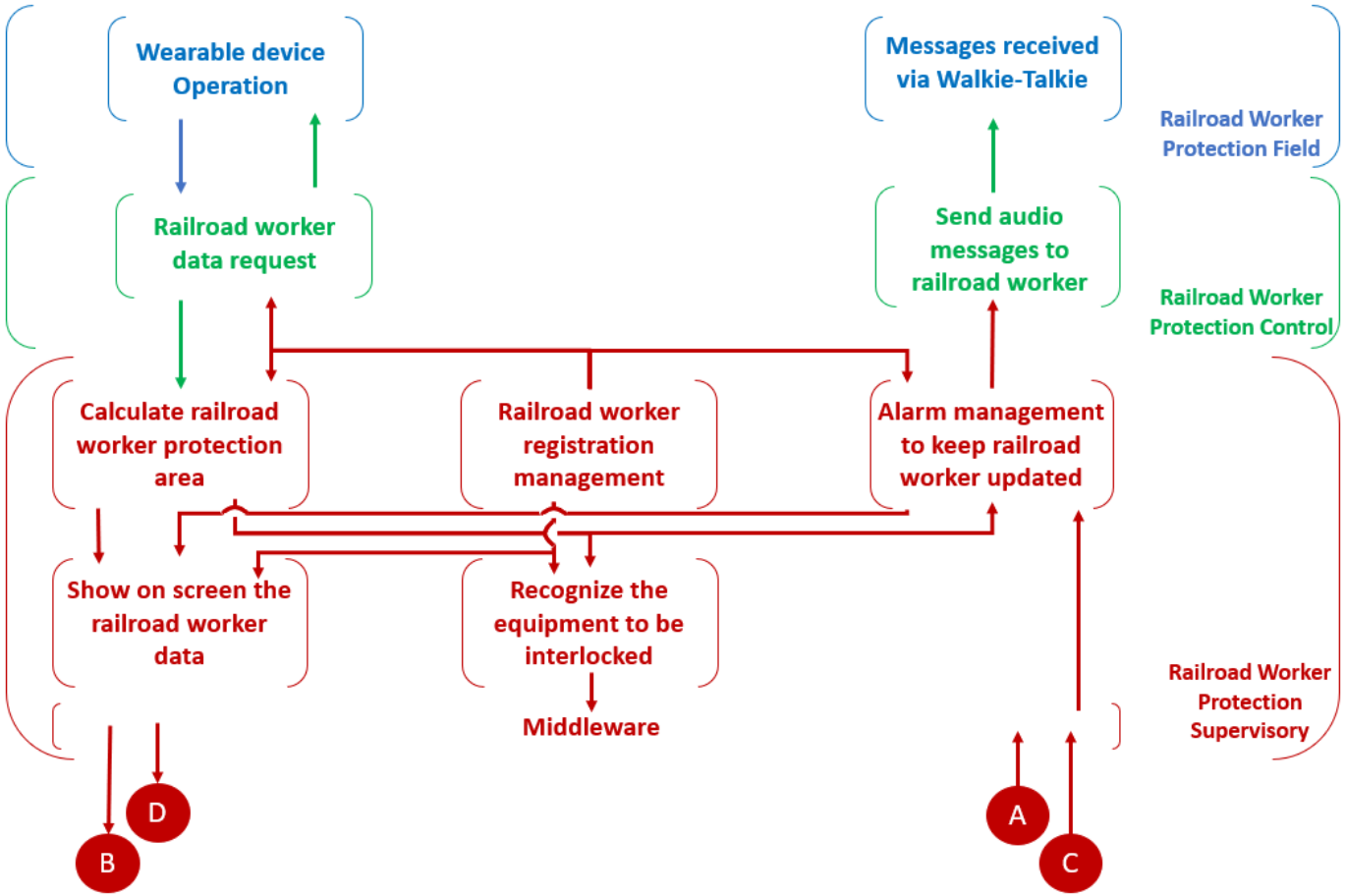
Metro system architecture: SCS models

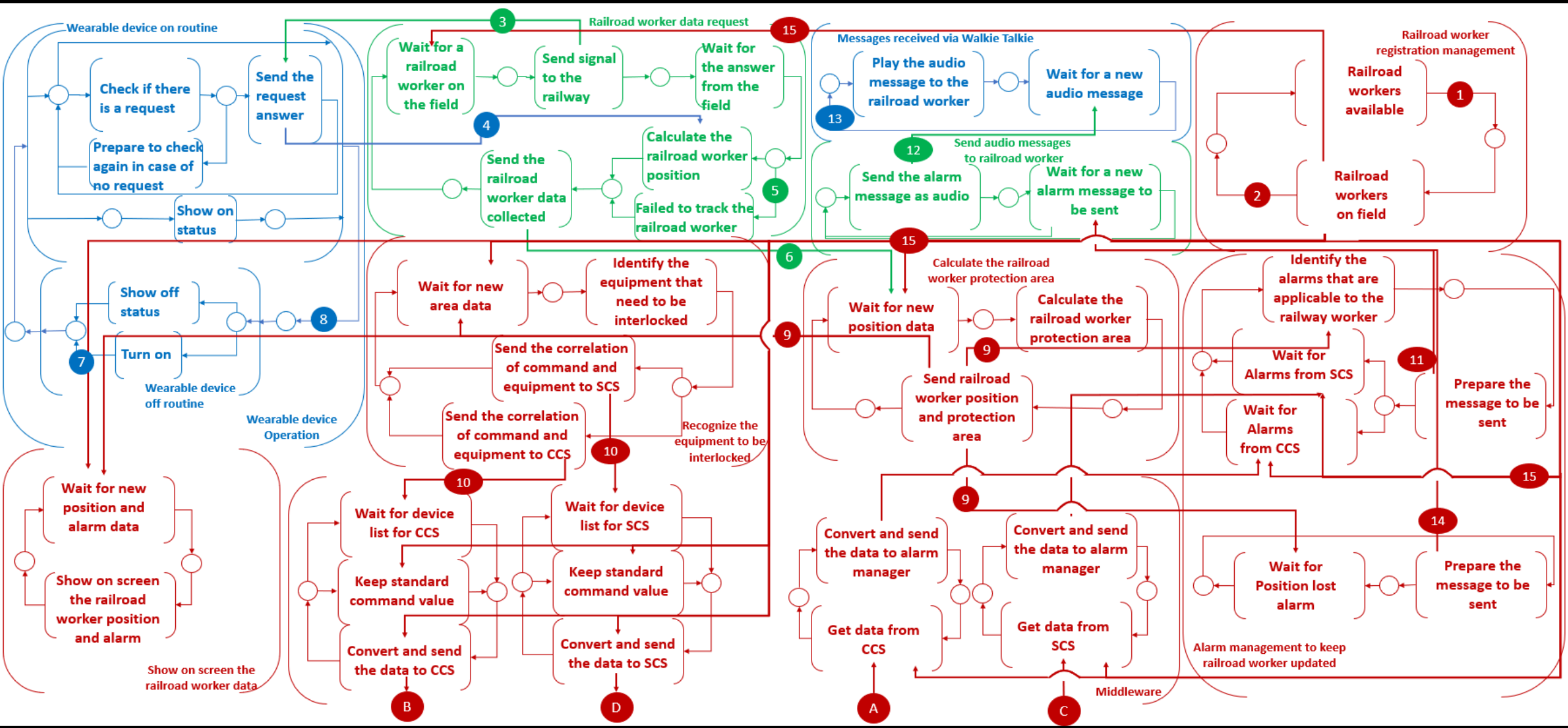




Railroad worker protection system architecture model






Wearable device on routine
Check if there is a request
Send the request answer
Prepare to check again in case of no request
Show on status
Show off status
Turn on
Wearable device off routine
Wearable device Operation
Railroad worker data request
Wait for a railroad worker on the field
Send signal to the railway
Wait for the answer from the field
Calculate the railroad worker position
Send the railroad worker data collected
Failed to track the railroad worker
Messages received via Walkie Talkie
Play the audio message to the railroad worker
Wait for a new audio message
Send audio messages to railroad worker
Send the alarm message as audio
Wait for a new alarm message to be sent
Railroad worker registration management
Railroad workers available
Railroad workers on field
Wait for new area data
Identify the equipment that need to be interlocked
Send the correlation of command and equipment to SCS
Send the correlation of command and equipment to CCS
Recognize the equipment to be interlocked
Calculate the railroad worker protection area
Wait for new position data
Calculate the railroad worker protection area
Send railroad worker position and protection area
Identify the alarms that are applicable to the railway worker
Wait for Alarms from SCS
Wait for Alarms from CCS
Prepare the message to be sent
Wait for new position and alarm data
Show on screen the railroad worker position and alarm
Show on screen the railroad worker data
Wait for device list for CCS
Wait for device list for SCS
Keep standard command value
Keep standard command value
Convert and send the data to CCS
Convert and send the data to SCS
B
D
Convert and send the data to alarm manager
Convert and send the data to alarm manager
Get data from CCS
Get data from SCS
A
C
Middleware
Wait for Position lost alarm
Prepare the message to be sent
Alarm management to keep railroad worker updated

Conclusion

- Metro system is essential for urban cities and can be considered as a legacy system;
- Accidents reported claim for a protection architecture for the railroad workers. This can be accomplished by the railroad worker protection system architecture;
- This new architecture will:
  - Facilitate the operator work from OCC;
  - Automatically protect the railroad worker;
  - Increase the communication between railroad workers and OCC;
  - Interface with the metro one through the SCADA layer.
- The railroad worker architecture was built in PFS to present its structure and interface with the metro one.
- As future work, it will be converted to CPN for validation.

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