CBTC 2.0
Vehicle Centric Architecture & Train to Train Communication

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CBTC 2.0 ARCHITECTURE
Departure from Tradition
CBTC 1.0 - Architecture

- Classic CBTC 1.0 Architecture
- First generation of CBTC technology
• Zone Controller is removed
CBTC 2.0 - Architecture

- ZC functions are shifted to the VC & IOC
- Vehicles communicate with each other (VC to VC communication).
- VC and ATS communicate directly with the IOC
- Vital System Database maintains system info
CBTC 2.0 - Architecture

- Focus of this presentation will be
  - ZC functions transferred to the VC
  - ZC functions transferred to the IOC
  - VSDb
TRAIN TRACKING

If a train cannot be tracked, it cannot be protected
The VC’s report their position to ZC1 (position report).
ZC1 tracks all VCs (trains) in the system based on their position reports.
Position integrity checks are performed by ZC1 to ensure the position is accurate.
Trains are not aware of other trains.

- VC1 is not aware of VC2
CBTC 1.0 - Train Tracking

- If there is a failure, such as a communication failure, ZC1 will create a buffer around the train.
- ZC1 will prevent other trains from entering this area.
CBTC 2.0 - Train Tracking

- VC2 communicates with the VC in front and behind creating an awareness of all trains in the vicinity.
- VC2 will perform position integrity checks on the position reports received from the other VC’s.
CBTC 2.0 - Train Tracking

- VC2 communicate with the VC in front and behind creating an awareness of all trains in the vicinity.
- VC2 will perform position integrity checks on the position reports received from the other VC’s.
- If there is a failure, such as a communication failure, VC2 will create a buffer around the train.
- VC2 will report the failure and the buffer boundary to the VSDb.
- VSDb will update all VC’s in the system of the failed train and buffer boundary.
INTERLOCKING
The ATS requests a route for VC1 that requires the switch to be in the normal position.
CBTC 1.0 – Interlocking

- The ATS requests a route for VC1 that requires the switch to be in the normal position.
- If the switch can be reserved for VC1, ZC1 will command the switch to move to the normal position, lock and reserve the switch.
CBTC 1.0 – Interlocking

- When the train passes through the switch, ZC1 will release (unlock) the switch.
The IOC is an input/output controller configured for a switch. When controlling a switch, the IOC will:
- Command the switch to normal or reverse.
- Lock the switch.
- Read status.
- Send statuses to the ATS and to any VC communicating with the IOC.
- Receive switch commands from the VC and ATS.
CBTC 2.0 – Interlocking

- The ATS will send a route to VC1 that goes through the switch.
- When VC1 is within range of the IOC, VC1 will:
  - Establish a communication link with the IOC
  - Command the IOC to move the switch to normal and lock the switch.
- The IOC will command the switch to move normal, lock and & reserve the switch and send the switch position to VC1.
CBTC 2.0 – Interlocking

- When the train passes through the switch, VC1 will send a release switch command to the IOC and terminate the communication link.
- The IOC will release (unlock) the switch.
SAFE TRAIN SEPARATION & MOVEMENT AUTHORITY

How close to bring the trains
CBTC 1.0 – Safe Train Separation

- ZC1 is aware of the status of all elements along the track such as switch status, location of trains and any other obstacle.
- Based on this information, ZC1 calculates the Movement Authority (MA) up to the first obstacle in the path of the train.
- ZC1 transmits the MA to VC2.
CBTC 1.0 – Safe Train Separation

- Based on the MA, VC2 will determine the stopping point.
- VC2 will stop the train at the stopping point.
CBTC 2.0 – Safe Train Separation

- VC2 is aware of all elements along the track such as:
  - Switch status via the IOC.
  - Location of other trains via the direct train to train communication link.
  - Other obstacles on the track via the VSDb such as failed trains or closed blocks.
CBTC 2.0 – Safe Train Separation

VC2 is aware of all elements along the track such as:
- Switch status via the IOC.
- Location of other trains via the direct train to train communication link.
- Other obstacles on the track via the VSDb such as failed trains or closed blocks.

Based on this information, VC2 will calculate the MA to the nearest obstacle.
• Based on the MA, VC2 will determine stopping point.
• VC2 will stop the train at the stopping point.
SCENARIO
Put it all Together
CBTC 2.0 – Scenario
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- VC1 will establish a communication link with the ATS and VSDb
CBTC 2.0 – Scenario

• VC1 will establish a communication link with the ATS and VSDb
• The ATS will provide VC1 with a destination.
• VC1 will calculate the MA and stopping point to the nearest obstacle.
• When VC1 is within range, VC1 will establish a communication link with the IOC controlling the switch and send a command to move the switch to the normal position.
• The IOC will command the switch to move normal, lock and reserve the switch.
CBTC 2.0 – Scenario

- Once the switch is in the normal position, VC1 will determine the next obstacle (VC2).
- VC1 will establish a communication link with VC2 and receive speed and direction of travel information.
- The MA and stopping point will move past the switch to VC2.
CBTC 2.0 – Scenario

- As VC2 moves forward, VC1 will move the MA and stopping point forward.
- When VC1 passes the switch, VC1 will send a release switch command to the IOC and terminate the communication link.
- The IOC will release the switch.
ADVANTAGES OF CBTC 2.0

Vehicle Centric Architecture and the new way.
Advantages of CBTC 2.0

• Improved Safe Braking Model
• Shorter Headways
• Reduced response times
• Reduced equipment
• Increased reliability and maintainability
This safe braking model is based on IEEE 1474.1-2004 Annex D. The safe braking model assumes VC2 is stationary and the safety distance is based on this assumption. If VC1 emergency brakes, it would stop just short of the brick wall. The safety distance is unnecessarily long because VC2 is moving away from the brick wall while VC1 is emergency braking the train.
• Since the trains communicate with each other, VC1 is aware of the speed of VC2 and travel direction.
• Therefore, VC1’s safety distance can overlap into VC2.
• If VC1 were to emergency brake, by the time it reached VC2, VC2 will have moved away.
CBTC 2.0 - Safe Braking Model

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Allows trains to travel closer together and keep the safety distance as short as possible.
CBTC 2.0 – Shorter Headways

- Headway is affected by various factors such as the turn back design and dwell times but the safety distance is also a factor. The above diagram is an over simplification to illustrate a point.
- A benefit of the reduced safety distance is the headway between trains is also reduced.
- More trains can move through the system.
CBTC 2.0 – Faster Response Time

CBTC 1.0 Loss of Switch Correspondence

CBTC 2.0 Loss of Switch Correspondence

Delay = A + B + C + D + E + F msec

Delay = A + B + C + D msec
CBTC 2.0 – Faster Response Time

**CBTC 1.0 Train Timeout**

- Central Control
  - NMS
  - PIS/PAS
  - Master Clock
  - WS
- ATS
- ZC
- Ethernet Network TCP/IP
- Radio Network TCP/IP

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- Central Control
  - NMS
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Delay = A + B + C msec

Delay = A msec
CBTC 2.0 – Less Equipment

- Reduced Equipment
  - The hardware for the ZC is no longer required

- Increased Reliability and Maintainability
  - Less equipment to fail
  - Less equipment to maintain
CBTC 2.0 – Disadvantage

• Radio Network
  • The latency on the wireless network is greater due to the number of links the VC has to establish.
  • Major impediment to implementation.
CONCLUSION
Conclusion

• CBTC 2.0 is a radical departure from the first generation CBTC architecture.

• CBTC 2.0 offers:
  • Improved headway by reducing safety distances.
  • Improved safety by reducing response times.
  • Increased reliability and reduced maintenance due to less equipment.

• Disadvantage is the wireless network latencies.
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