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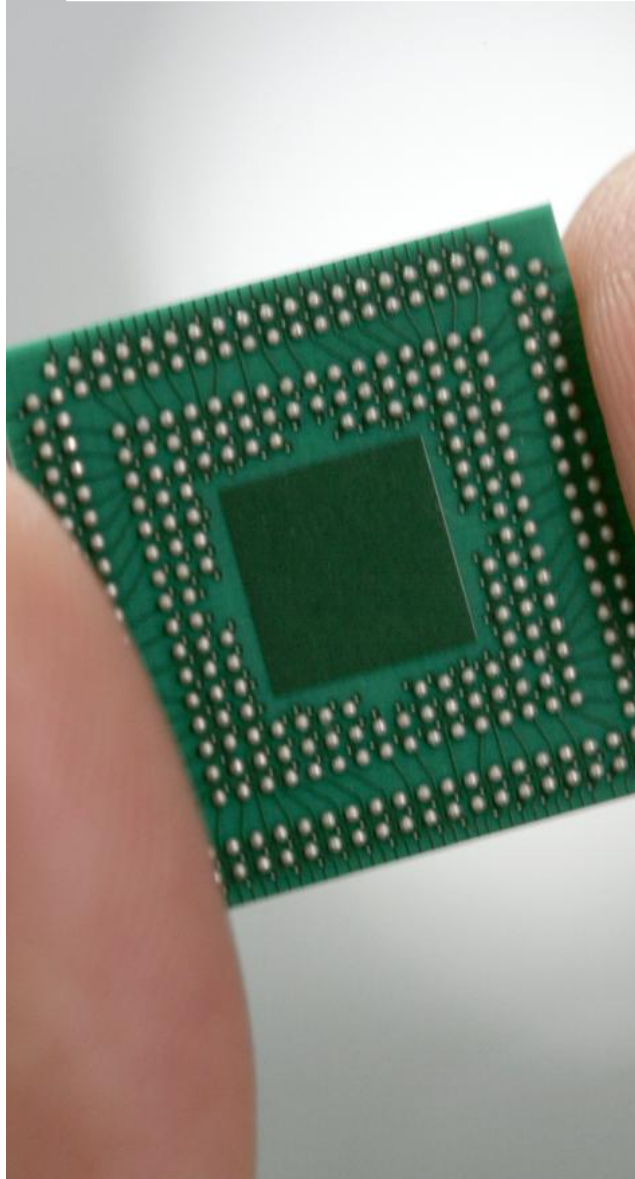# L2 Routing for Control Data Traffic @ Industry

2012-09-10

IEEE 802.1 Meeting – Santa Cruz

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NEW IDEA
ISIS-SPB for Audio/Video- or Control-Data-Streams

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Characteristics of Streams (I):

- Own traffic class for streams (priority tag is used for separation)
  - Audio-Video (AV) streams
    - AV streams high, class A, e.g. default priority 3
    - AV streams low, class B, e.g. default priority 2
  - Control Data (CD) streams
    - CD streams high, class A, e.g. default priority 6
    - CD streams low, class B, e.g. default priority 5
- Unique destination address (using engineered multicast and unicast addresses for streams)
- Unidirectional traffic (no feedback)

- *continued on next slide*

NEW IDEA
ISIS-SPB for Audio/Video- or Control-Data-Streams

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Characteristics of Streams (II):

- Time sensitive traffic (low latency)
- Fixed transmission period
  - Audio-Video (AV) streams
    - AV streams high, 125µs transmission period
    - AV streams low, 250µs transmission period
  - Control Data (CD) streams
    - CD streams high, one common transmission period per area in range between 31.25µs – 250µs
    - CD streams low, one common transmission period per area in range between 250µs – 1ms
- Typical frame size for streams in the range of 64 to 400 bytes
- Reserved bandwidth for streams
  - Limited number of CD streams and AV streams in a convergent network
- Connectivity p2p or p2m (one talker -> multiple listeners, n2m seldom)
  - Typically a limited number of talkers / listener
- Limited areas (domains, domain boundary)
  - No inter domain communication for Control Data Streams
- ...

Control Data Streams

Control Data:

- data frames

- specific requirements derived from applications in industrial automation and automotive (e.g. low latency, high reliability)

- often specific characteristics (e.g. periodic small size frames)

Control Data Streams:

- control data is sent as streams

- continuous control data traffic during operation of industrial plant etc.

- similar to AV streams (but higher requirements)
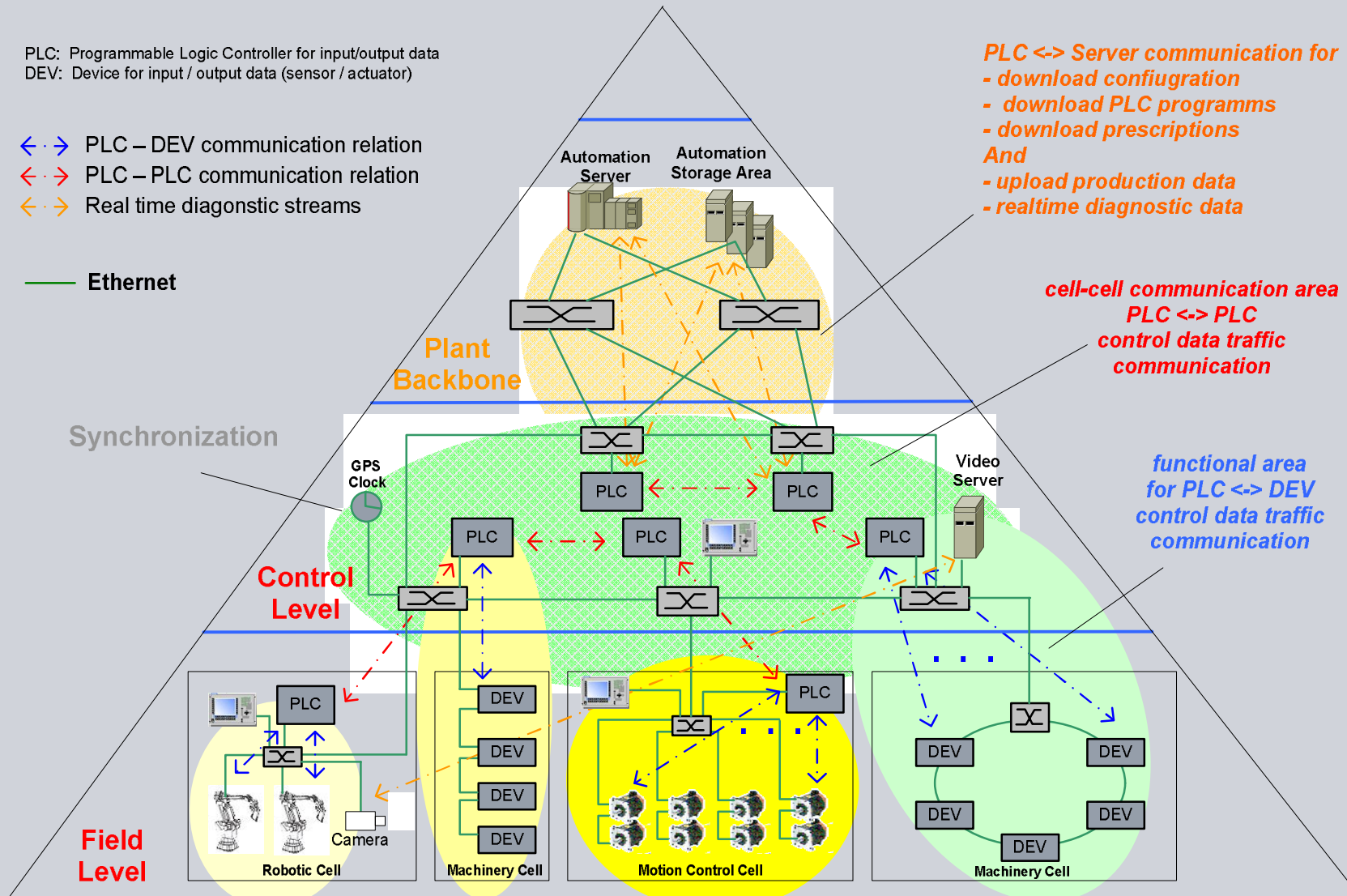
- high reliability necessary

Industrial Communication
within one network @ Industry

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PLC: Programmable Logic Controller for input/output data
DEV: Device for input / output data (sensor / actuator)

←··→ PLC – DEV communication relation
←··→ PLC – PLC communication relation
←··→ Real time diagonstic streams

——— **Ethernet**

Synchronization

Plant Backbone

Control Level

Field Level

Automation Server
Automation Storage Area

GPS Clock

Video Server

PLC   PLC
PLC   PLC   PLC

PLC

PLC

DEV
DEV
DEV
DEV

DEV
DEV
DEV
DEV
DEV

Robotic Cell
Machinery Cell
Motion Control Cell
Machinery Cell

Camera

PLC <-> Server communication for
- download confiugration
- download PLC programms
- download prescriptions
And
- upload production data
- realtime diagnostic data

cell-cell communication area
PLC <-> PLC
control data traffic
communication

functional area
for PLC <-> DEV
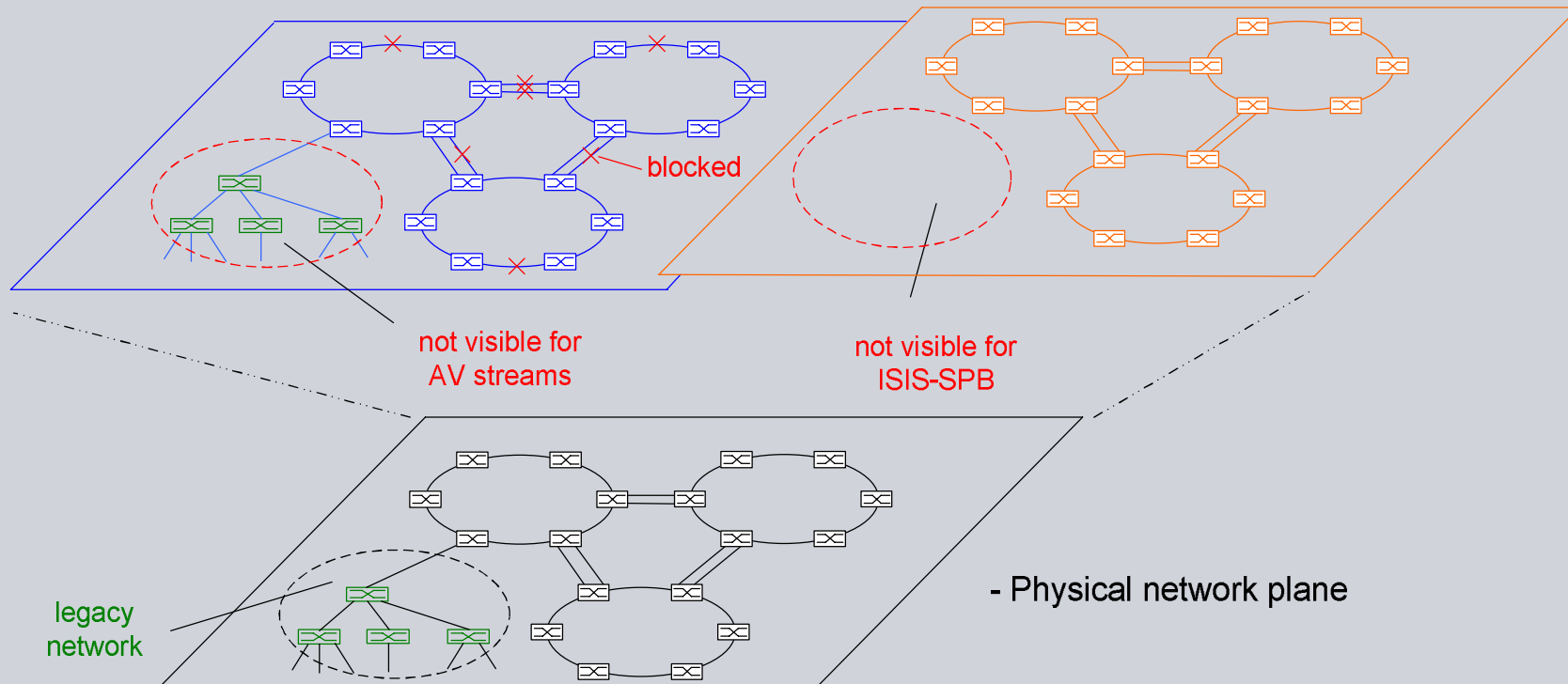*control data traffic*
communication

IDEA
Typical Industrial Network Layer Model

Forwarding path control protocols (RSTP, MSTP, SPB) are required for convergent networks to avoid communication loops for

- *Best effort traffic*
- *AV Streams (Real time diagnostic data streams)*
- *ISIS-SPB for streams is used for Control Data traffic*

RSTP provides loopfree data tree for
Best effort traffic plane and
Audio/Video streams

ISIS-SPB for
Control Data traffic

blocked

not visible for
AV streams

not visible for
ISIS-SPB

legacy
network

- Physical network plane

Communication Characteristics
for Control Data Traffic in Industry

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Production line consists of

- **Topology**
  - up to 2000 nodes
  - max. 64 hops per ring
  - multiple network segments (join, divide of areas at runtime)

- **The relationship between source and destination(s) is already known**
 - Derived from industrial application
  - Higher layer protocols (establish connectivity)
  - Planning with engineering tool

- **A typical control network is a hierarchical network which consists of**
  - A small number of PLCs communicating with a huge number of sensors and actuators (n : m)
  - A huge number of sensors and actuators communicating with a small number of PLCs (m : n)
  - Only the small number of PLC may communicate with each other

- **The communication for control data is typically bidirectional (sensor/actuator)**
  - Symmetric paths are expected (equal latency for both directions)
  - However, streams are unidirectional → one stream for each direction

-
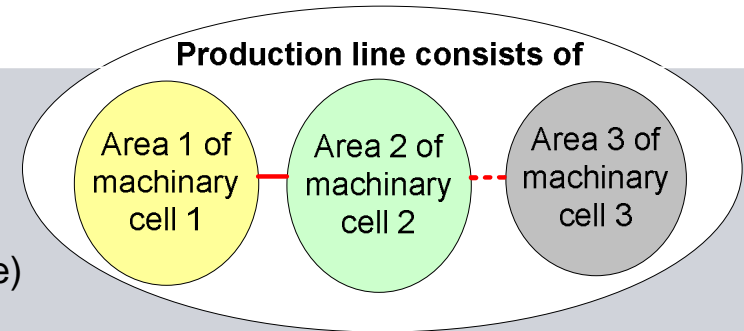
Communication Characteristics
for Control Data Traffic in Industry

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Dynamics of Topology Changes :

▪ **Add new device (sometimes)**
- $\Rightarrow$ Incremental routing for paths to new device
- $\Rightarrow$ New streams – incremental reservation

▪ **Link failure (very rare)**
- ▪ Caused by mechanical stress (cable, connector)

▪ **Device failure (very rare)**

▪ **Lifetime of streams (very long)**
- ▪ hours
- ▪ days
- ▪ years

▪ **Bandwidth requirements for control data traffic (very stable)**

▪ **Changes to network segment(s) (sometimes)**
- • triggered by partial changes to production line

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ISIS-SPB for Audio/Video- or Control-Data-Streams

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Requirements for Streams:

- **Single path connection**
    - Setup routing at startup
    - Re-routing after link error
    - re-routing or add routing shall not disturb Control Data stream flows which were not directly affected by the link failure

- **Multi path / redundant path connection**
    - Setup routing at startup
    - No immediate re-routing on link-breaks or bridge failures (redundant transmission, i.e. strict 1+1 protection) → seamless redundancy for high availability
    - re-routing or add routing shall not disturb Control Data stream flows which were not directly affected
    - Support single and dual/multiple homing
    - Use of maximal disjoint paths

- **Multiple talkers for one stream**
    - Identical streams (e.g. microphone, redundant sensors) generated at different sources at the same time

IDEA
ISIS-SPB for Audio/Video- or Control-Data-Streams

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- two VLANs – one for primary path, one for secondary path

- separation by VLAN ID in order to support multiple traffic classes with different quality of service within a network

- address learning not required, FDB is set by routing algorithm

- ISIS-SPB used for exchange of link state information

- different routing method (multi-path)

- routing based on customer MAC addresses (= unique multicast MAC addresses)

- no differentiation between customer and backbone networks at field and control level → a convergent network is required

IDEA
ISIS-SPB for Audio/Video- or Control-Data-Streams

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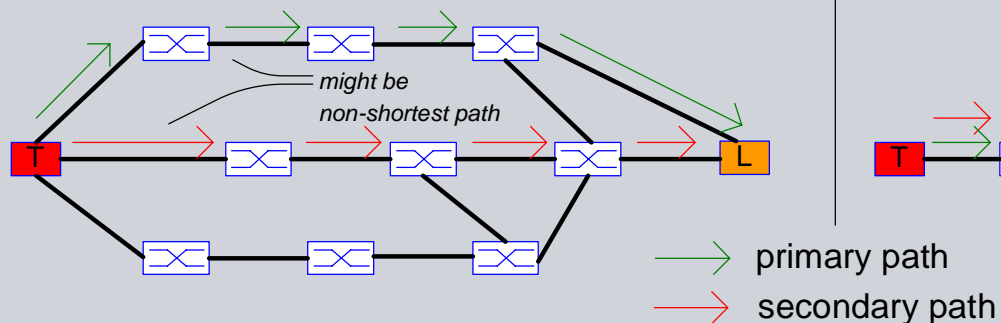**Requirements on multipath routing: Single homing and dual / multi homing**

Assumption: one VLAN for primary path and one VLAN for secondary path

T talker – dual/multi homing
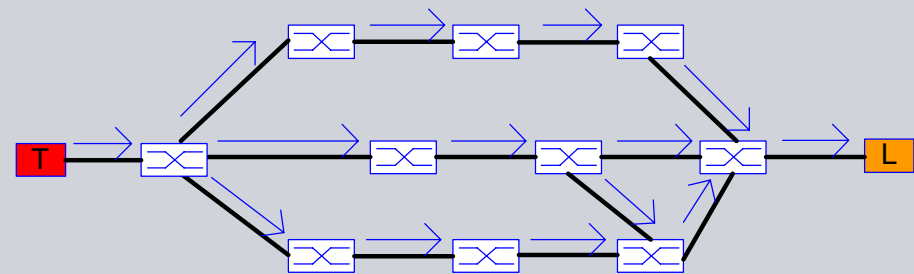**L listener- dual/multi homing**

T talker – single homing
L listener- single homing

- all possible paths are usable -

- all possible paths are usable -

No bridging supported

- link disjont and node disjont shortest path pair -
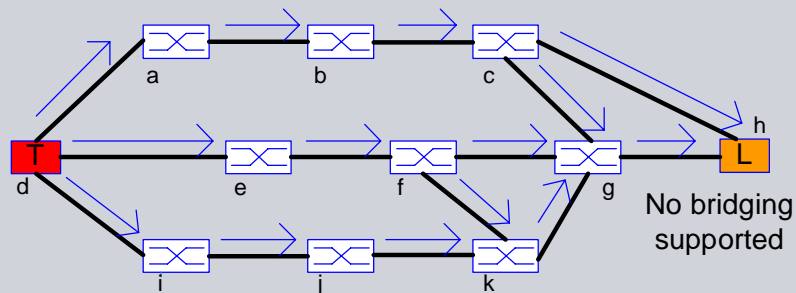
- max disjoint shortest path pair -

might be non-shortest path

might be non-shortest path

→ primary path
→ secondary path
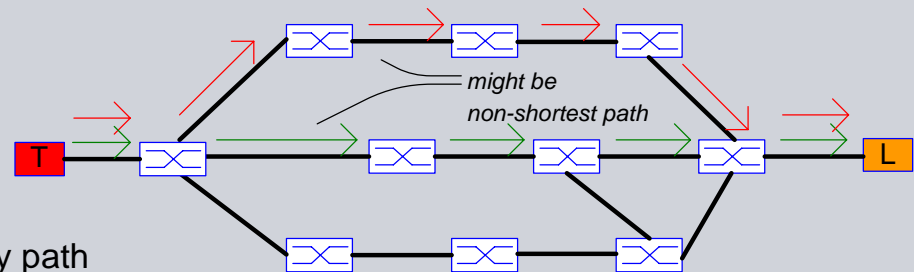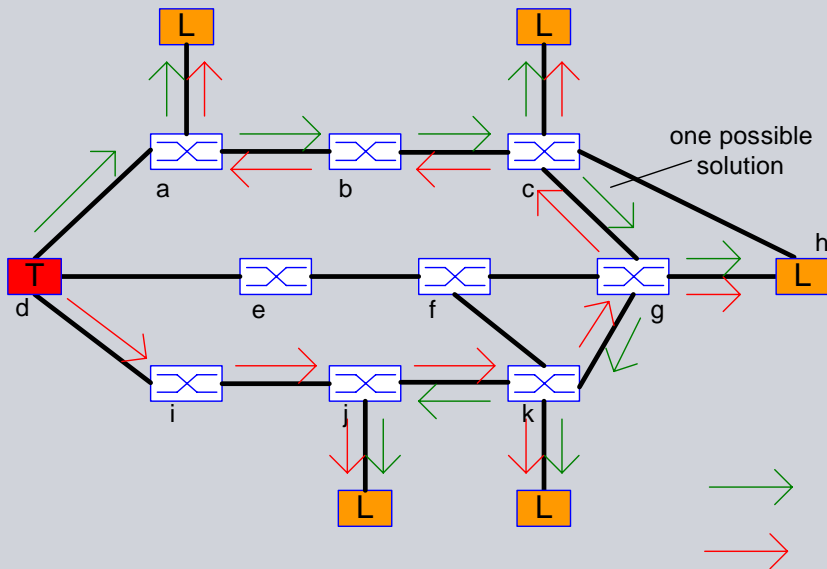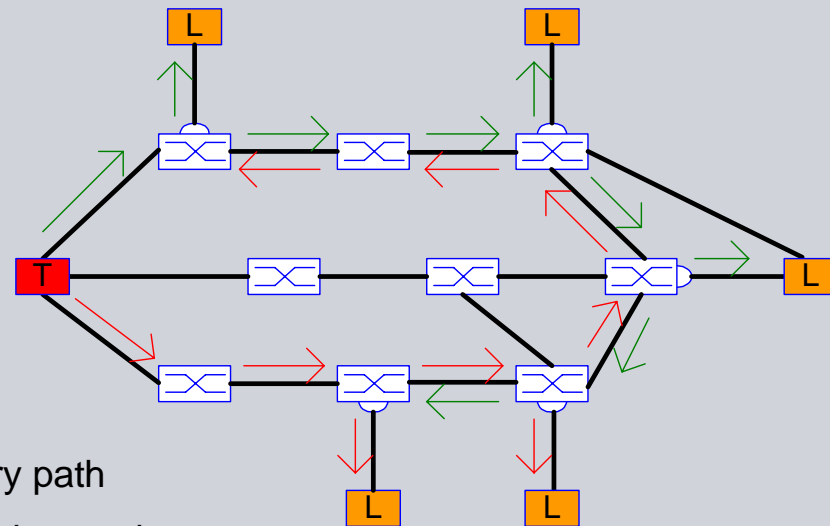
Requirements on multipath routing: Multicast (1:m – one talker, multiple listeners)

T talker – dual/multiple homing
L listener- dual/multiple/single homing

- multicast routing for streams -
- one common stream for multiple listeners -

- multicast routing for streams -
- one common stream for multiple listener –
- option: duplicate filtering on bridge edge ports with encapsulation for sequence number and ID for stream -

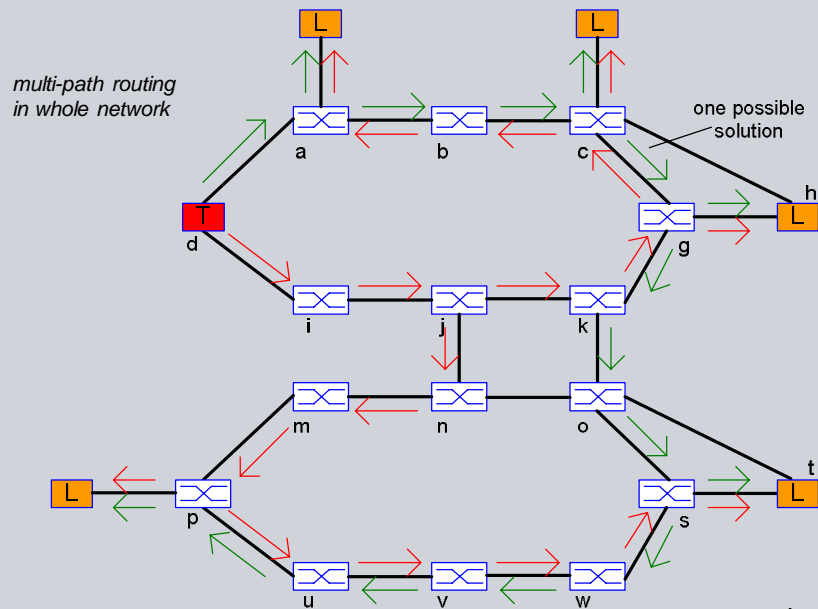one possible solution

primary path

secondary path

Requirements on multipath routing: Multiple Network Segments (Network Segment Protection)
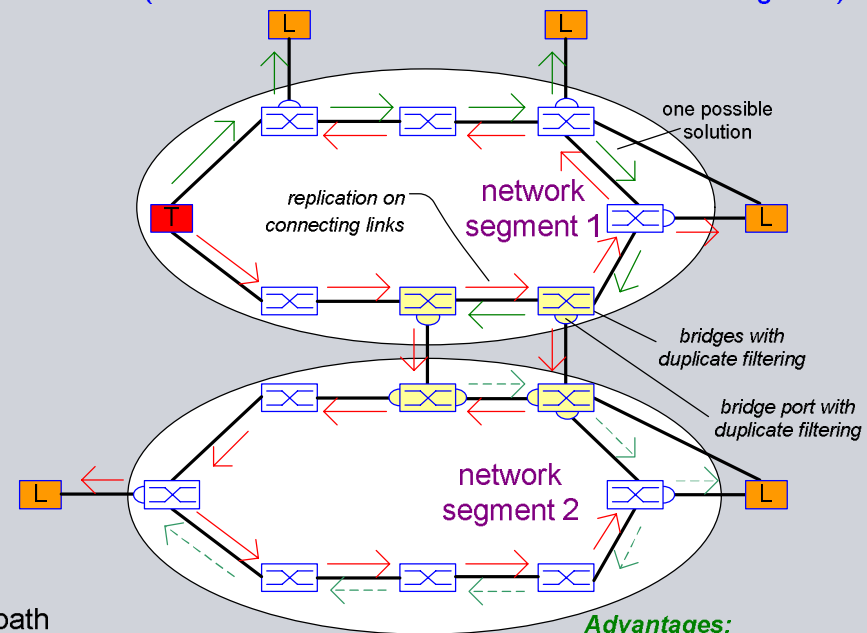
T talker – dual/multiple homing
L listener- dual/multiple/single homing

- multicast routing for streams -
- one common stream for multiple listener –
- no single point of failure in whole network
  (reliable with one failure within whole network) -

- multicast routing for streams -
- one common stream for multiple listener –
- per stream duplicate filtering on bridge ports with encapsulaton of sequence number and ID for streams -
- no single point of failure in each network segment
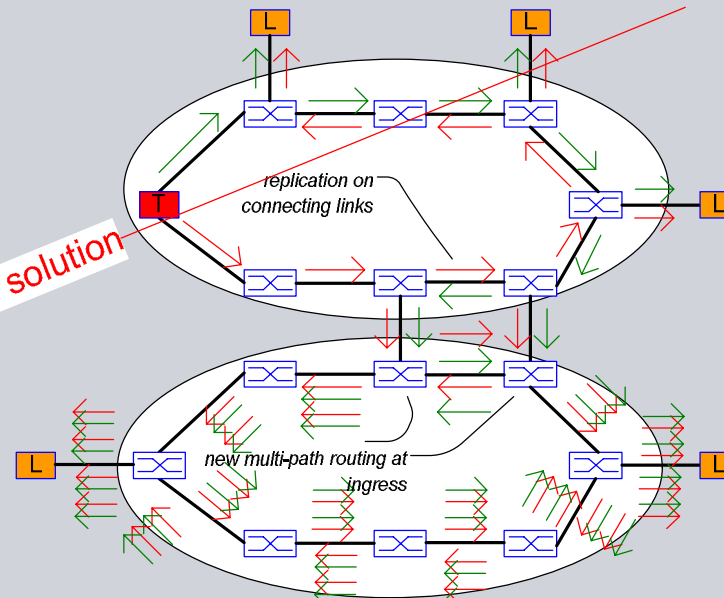 (reliable with one failure within each network segment) -

multi-path routing in whole network

one possible solution

replication on connecting links

network segment 1

bridges with duplicate filtering

bridge port with duplicate filtering

network segment 2

primary path

secondary path

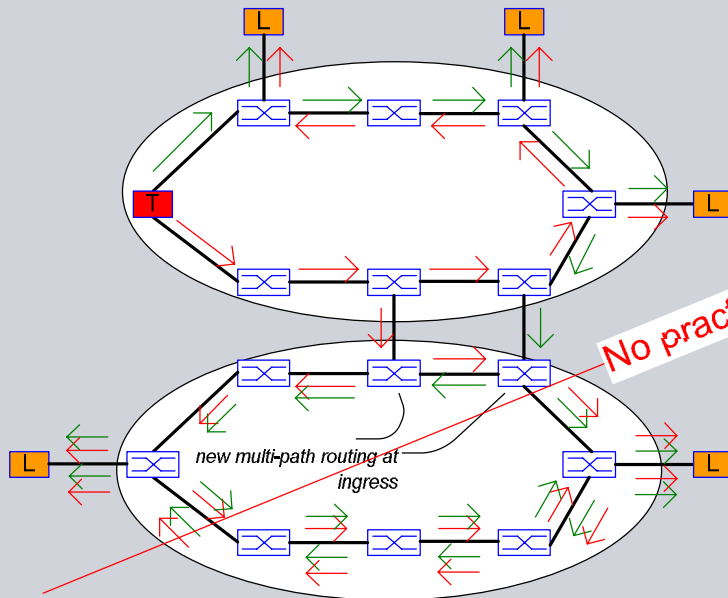copy of frame from primary or secondary path + tagging on egress port

Advantages:
- low bandwidth consumption
- learning allowed

Requirements on multipath routing: Multiple Segments

T talker – dual/multiple homing
L listener- dual/multiple/single homing

- multicast routing for streams -
- one common stream for multiple listener –
- **no duplicate filtering -**
- no single point of failure in each segment
(reliable with one failure within each segment) -

- multicast routing for streams -
- one common stream for multiple listener –
- **no duplicate filtering -**
- no single point of failure in each segment
(reliable with one failure within each segment) -

No practical solution

replication on connecting links

new multi-path routing at ingress

new multi-path routing at ingress

Constrains:
- huge bandwidth consumption without duplicate filtering
- no learning (problem with learning)

→ primary path
→ secondary path
- - → copy of frame from primary or secondary path + tagging on egress port

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Requirements on multi path routing: Multiple Talkers with identical streams

T talker – multiple talker, single homing
L listener- dual/multiple/single homing

- multicast routing for streams -
- common identical streams from multiple talkers for multiple listeners -

primary path for primary stream
secondary path for secondary stream
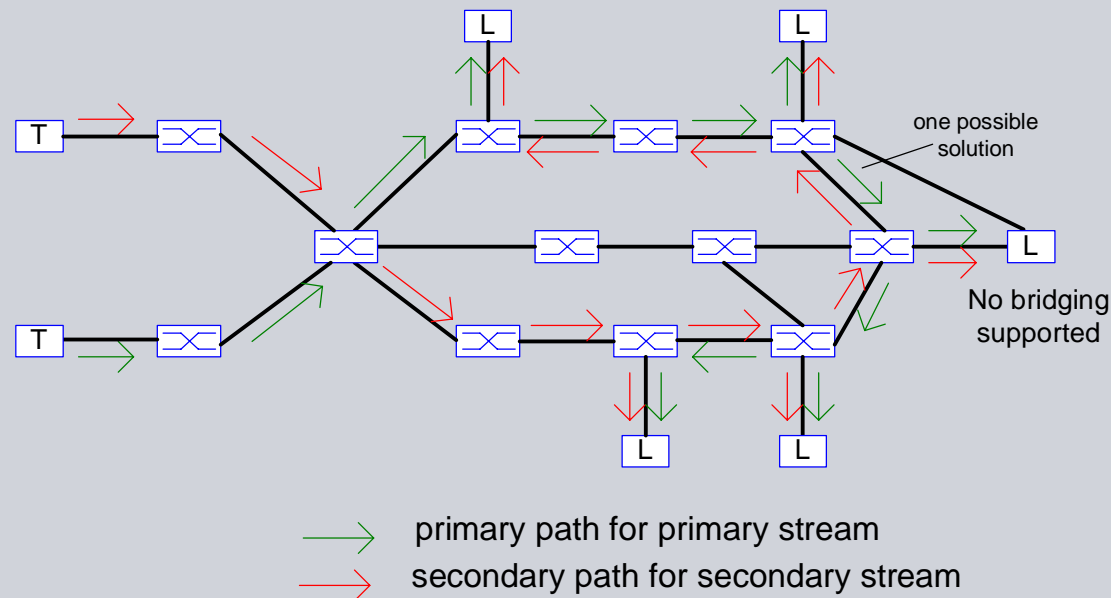
Identical streams (e.g. microphone) generated at different sources at the same time

IDEA
ISIS-SPB for Audio/Video- or Control-Data-Streams

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Benefits of SPB (as in 802.1Q):

- ISIS-SPB for information exchange (link state) between bridges
- uses customer MAC address (SPB-V)
- computes shortest paths between bridges (SPB)
- Supports virtualization within a VLAN, specifically per-service pruned multicast trees (SPB-VM, in different ways)
- runs within single VLAN ID (SPB-M)
- loop prevention

IDEA:

Use ISIS-SPB for Audio/Video Streams and Control Data Streams

- Plus some enhancements for streams (e.g. engineered paths, non-shortest paths, protection mechanisms such as 1+1 protection and network segment protection, bandwidth reservation for streams)
- SPB for Streams = subset of SPB (.1aq) + enhancements for streams

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Finish

Further Questions?