IEEE 802.3cg 10 Mb/s Single Twisted Pair Ethernet

CHARLOTTE: ELEVATOR/ESCALATOR USE CASE, TOPOLOGY AND FAILURE MODES

Introduction (elevators, global)

- Current network solutions:
  - Volume: mainly RS485-, CAN- and simple proprietary solution-based products
  - Sporadic: copper twisted pair point-to-point Ethernet (≤100m)
- On the worldwide market:
  - Currently: ≈850.000 new installations / year: each having avg. 20 serial port interfaces
  - 2020: ≈1.000.000 new installations / year
- Requirements of near-future systems (functional safety, voice and video streaming) can not be met using these networks
- Product's life (market-dependent):
  - life-span is 15-20 years
  - life-time is 15-30 years, replaced/modernized afterwards
- We can estimate that half of the 20 million nodes per year market could be Ethernet-based in ten years' time

Example of current network (ISO OSI)

- L1: RS485, ≤250 kbps (slew-rate limited), ≤4000f (≈1200m),
  half duplex/multidrop (≤128 PHY)
- Single 18-23AWG stranded shielded twisted pair (copper), with termination
- L2: Manchester, CSMA/CA (p-persistent), 16-bit CRC
- L3-L7: proprietary protocol
- Several types of connectors (pitch in the range of 3-5.08mm)
- Separate wires in the same cable/connector for power and configuration/discovery
- Network may be branched: 1 backbone, single-level branches off of it
  (each branch with ≤128 PHY)

Future network: bird's eye view

- Specific architecture:
  - Machine-room: high communication speed
  - Hoistway/landings: daisy-chain of switches serving smaller branches
  - Travelling-cable: point-to-point, long reach
  - Car: multiple devices, in confined space (short-reach)
- High level of flexibility with regards to hardware:
  - Cable
  - Connector (inline and IDC)
  - Details: twist, stripping etc.
- PHY
  - Commercial solution preferred
  - Till then solution should be possible to be implemented in ≤100MHz Cortex-M4/7 without FP, with ADC/DAC and native DSP (or similar)

Future network: details

- Elevators: two models used as building blocks
  - Model A: branches (or very simple real systems)
  - Model B: trunk
  - Model A+B: real systems of wide range (distance and number of nodes)
- Self-synchronizing or support for a drift inherent to crystals (200ppm over whole temperature range)
- Framing should allow the following message classes to be supported (in decreasing order of importance):
  - Isochronous: safety monitoring (10/s, max jitter 1ms)
  - Immediate: safety events (≤20/s, delivery within 1ms)
  - Ad-hoc (on-demand): events (≤200/s, delivery within 10ms without safety)
  - Realtime: audio and video (properties are TBD)
  - None (idle): burn unused bandwidth for telemetry, file transfer (no guaranteed service)

Future network: environment

- Systems:
  - Elevators: Two models
    - Model A: ≤16 nodes, ≤100m
    - Model B: ≤16 nodes, ≤1000m
    - Model A+B: 200(+) nodes, 1000(+)m
  - Escalators: Simple network with few (≤10) nodes and medium reach (≤50m), model A
  - Powerwalks: Simple network with few (≤10) nodes and medium reach (≤100m), model A
- Environmental conditions
  - Industrial conditions, with temperature range of -20°C – +65°C
- Electrical requirements
  - Overvoltage and ground fault protection ±40V
  - Short- and open-circuit protection
  - Electrostatic discharge protection (EN 61000-4-2) 15kV
  - Fast transient protection (EN 61000-4-4) 2kV

Future network: what is not considered (needed)

- Intrinsic safety
- Hot-plugging

Future network: model A (branches)

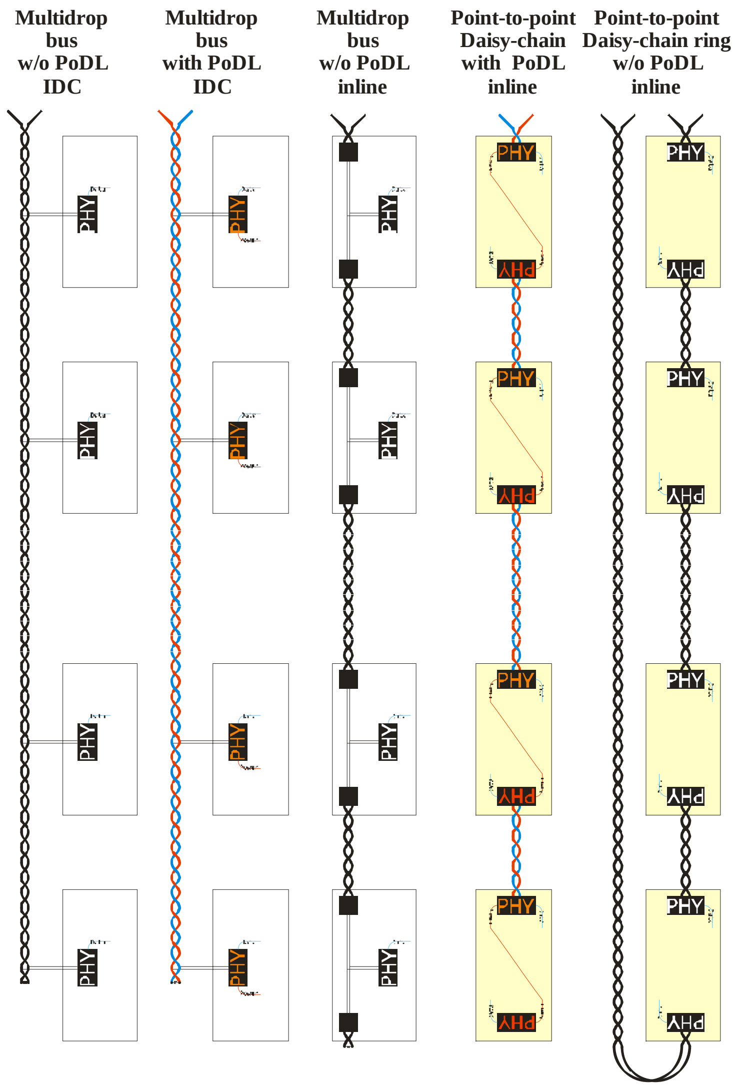
- Architecture: Single bus, 1 PHY/node (multidrop)
- Type: single shielded copper TP
  - As target is new device market (or when not, cables are replaced during modernization), there is high level of flexibility adopting external specs on cable and possibly on connectors
- Segment length: ≤100m
- Nodes: ≤16 nodes
- PoDL (Σ for 16 nodes): ≤50W (avg.), ≤100W (peak), 24-48DC
- Other factors:
  - Native topology discovery: desired (through software): installation-time automatic node self-configuration (based on node order and possibly approximate distance)
- Possible use:
  - Hoistway/andings segments
  - Small car

Future network: model B

- Same as model A, with exceptions:
  - Length: long- (≤1000m) and intermediate-reach (50-100m)
  - Point-to-point may be possible
  - PoDL not needed
- Possible use:
  - Long reach: travelling-cable: constant mechanical wear (known bending radius)
  - Intermediate reach: hoistway/landings (backbone for model A segments)
    - Cable may need to be weight-bearing (complete or part of own weight) with or without IDC

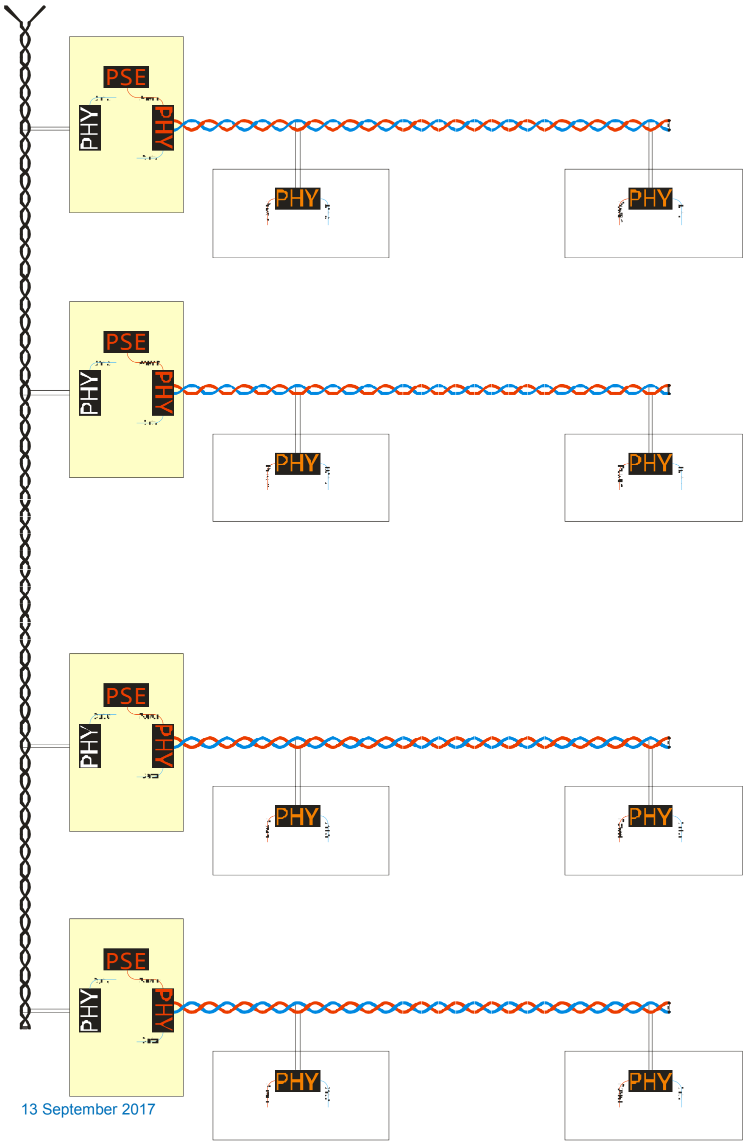
Future network: hybrid (complete network)

- Simplest elevators (volume):
  - A+B without segments
- Anything above:
  - A+B with appropriate amount and type of segments
  - Number of A segments is determined by system factors:
    - Floor distances (hoistway/landings image)
    - Powering requirements
    - Services (audio, video)
    - Need for redundancy

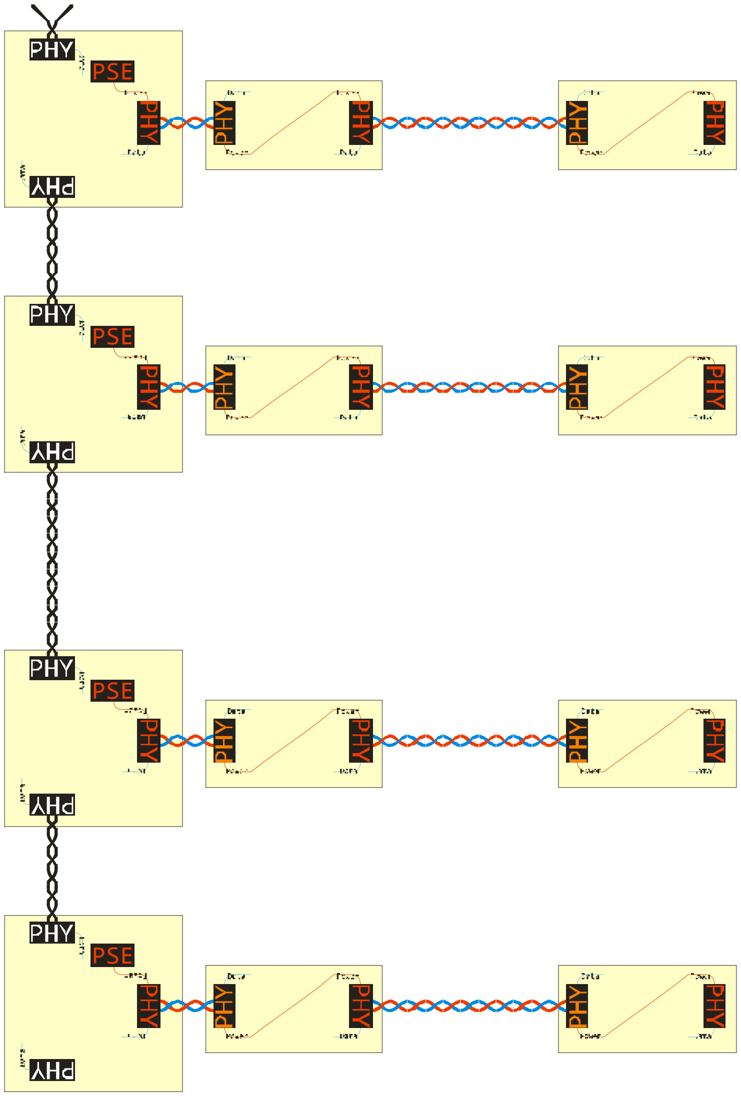


Legend:

- Connector:
  - 1, 2, 4 and 5: Insulation Displacement Connector (IDC)
  - 3: Inline
- PoDL
  - 2: with multidrop
  - 4: with point-to-point
- PHY/PSE:
  - White: no PoDL
  - Red: PoDL producer (source)
  - Orange: PoDL consumer
- Cable:
  - Blue-red: Carrying data and power (24-48VDC)
  - Black: Data only



- Multidrop
- Model B backbone with no PoDL
- Model A branches with PoDL
- PSE on branch master (switch)
- Connectors: IDC (but can also be inline
- Number of nodes is an example



- Point-to-point
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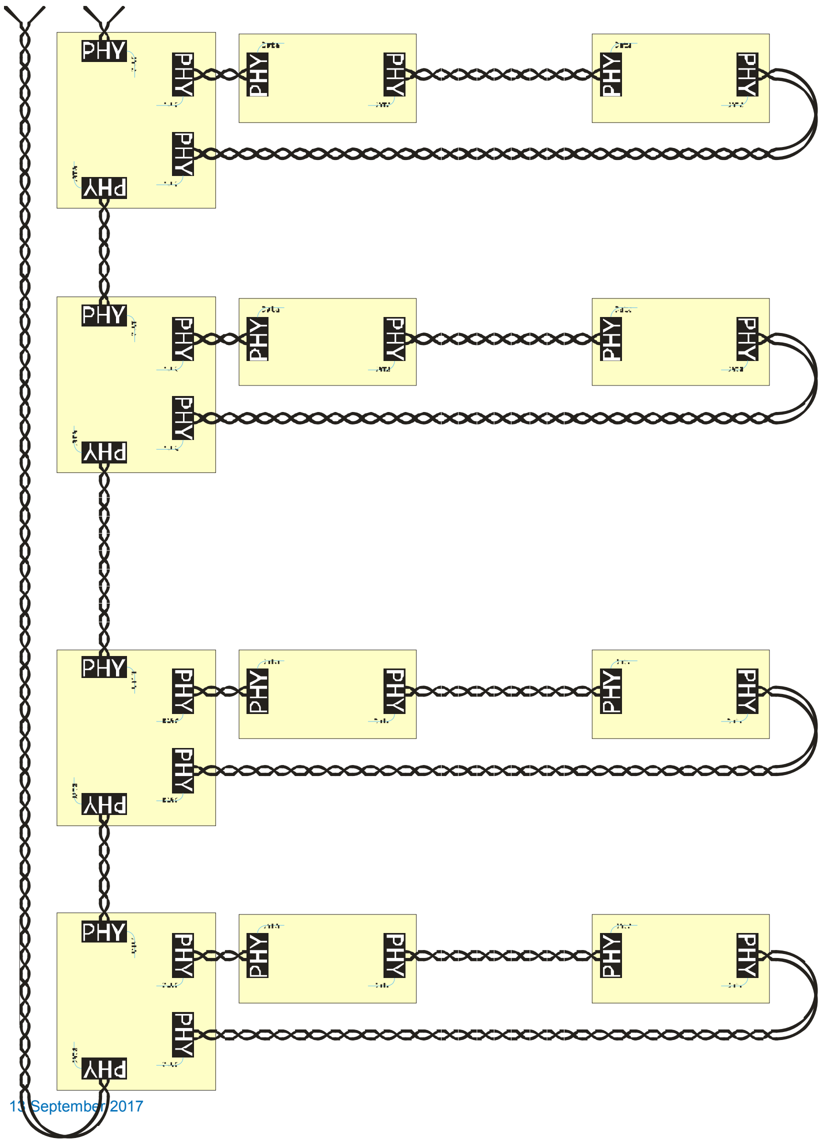

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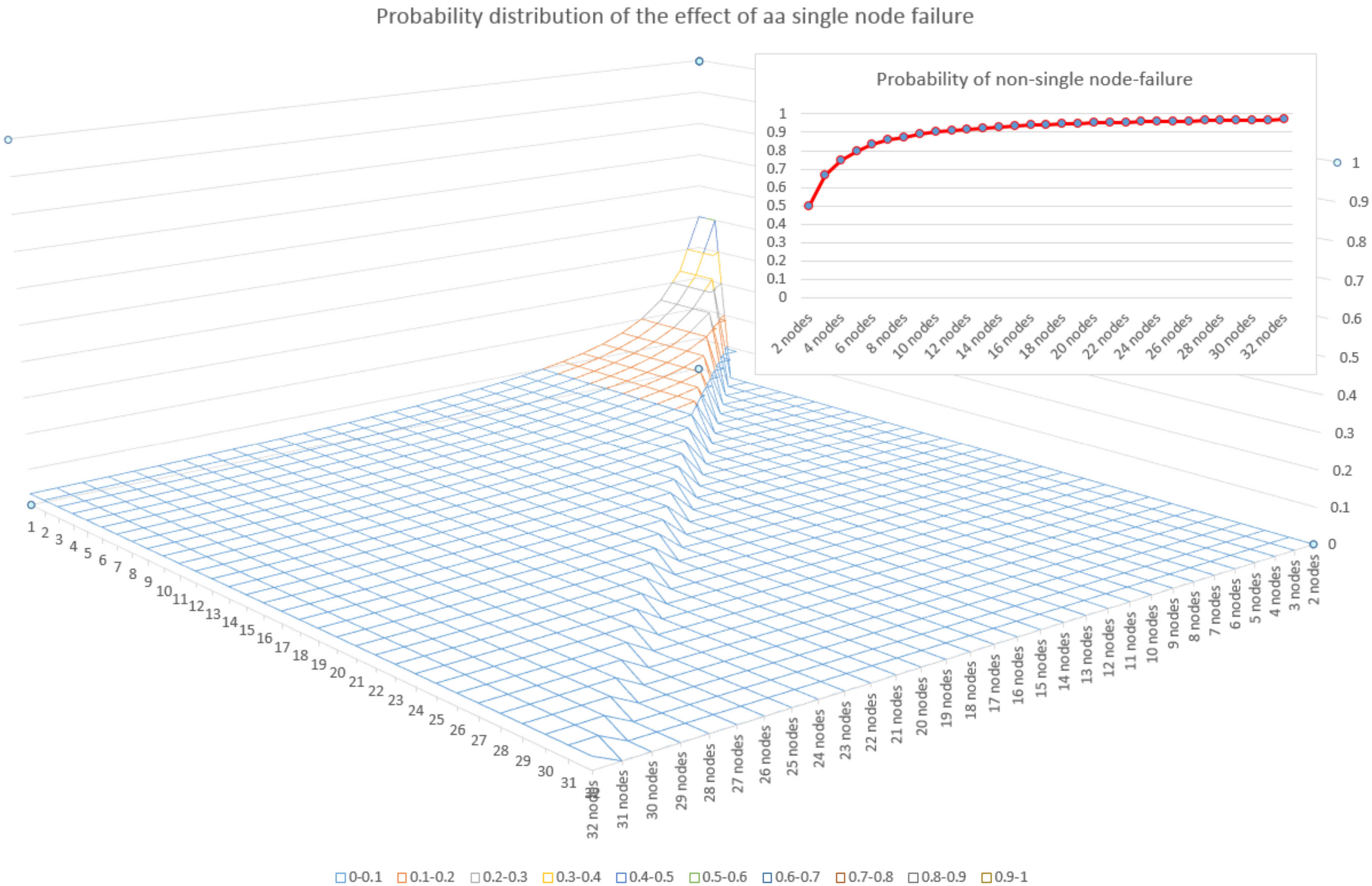
Comparison of reliability

- Simulations have been run to compare performance of point-to-point and that of multidrop
- Failure mode included
  - Node L2+ failures (switching entity/host processor failure)

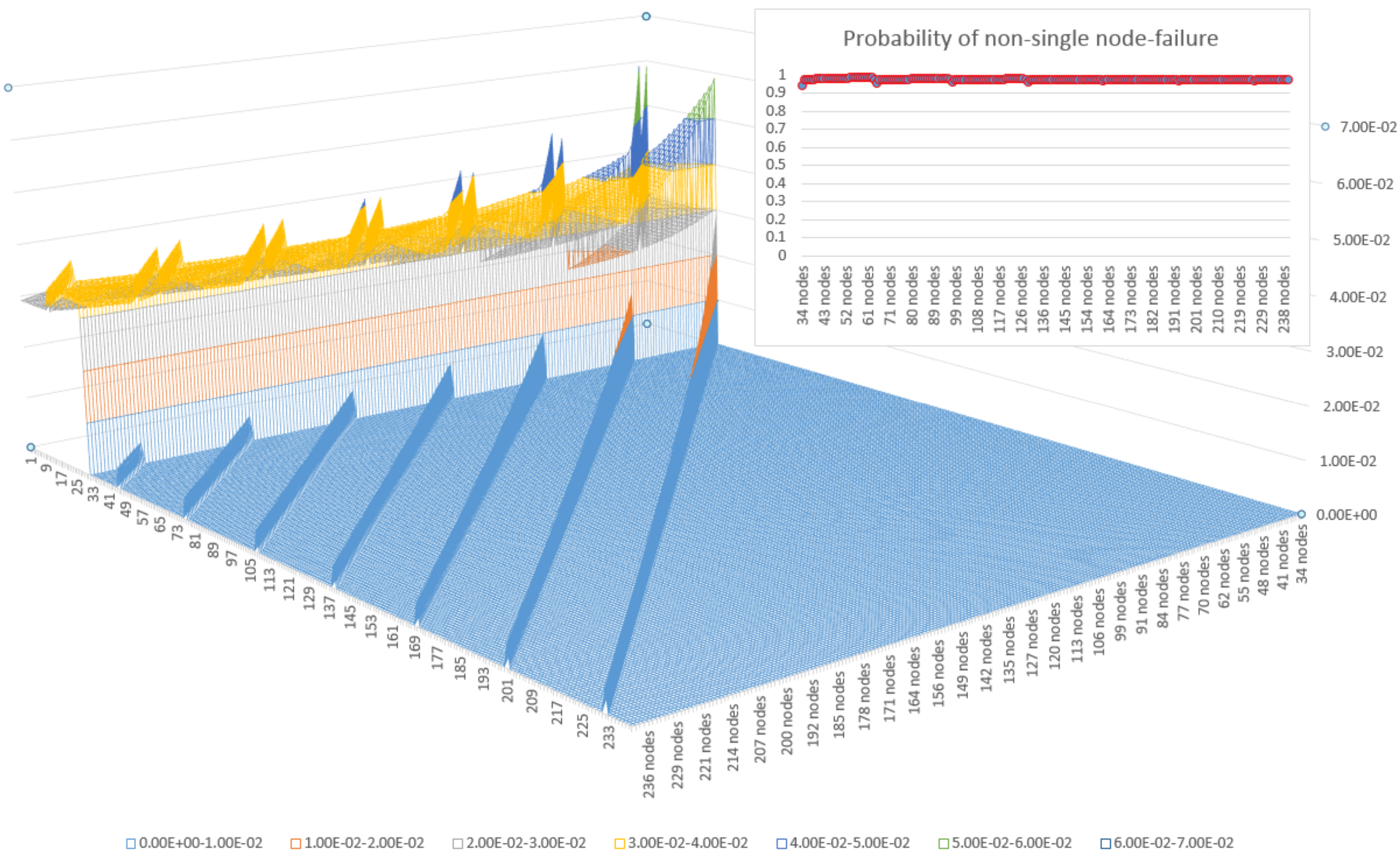
  and/or
  - PHY failures rendering only local node unable to send/receive (no bus short/bias)
- Simulations try to show the following 2 factors:
  - Surface: probability distribution of the number of node going offline due to a single failure
  - Line: probability of given networks lose more than 1 node due to a single failure
- Failures are equiprobable and memoryless

1-level point-to-point bus



2-level point-to-point bus

Probability distribution of the effect of aa single node failure



1-level multidrop bus

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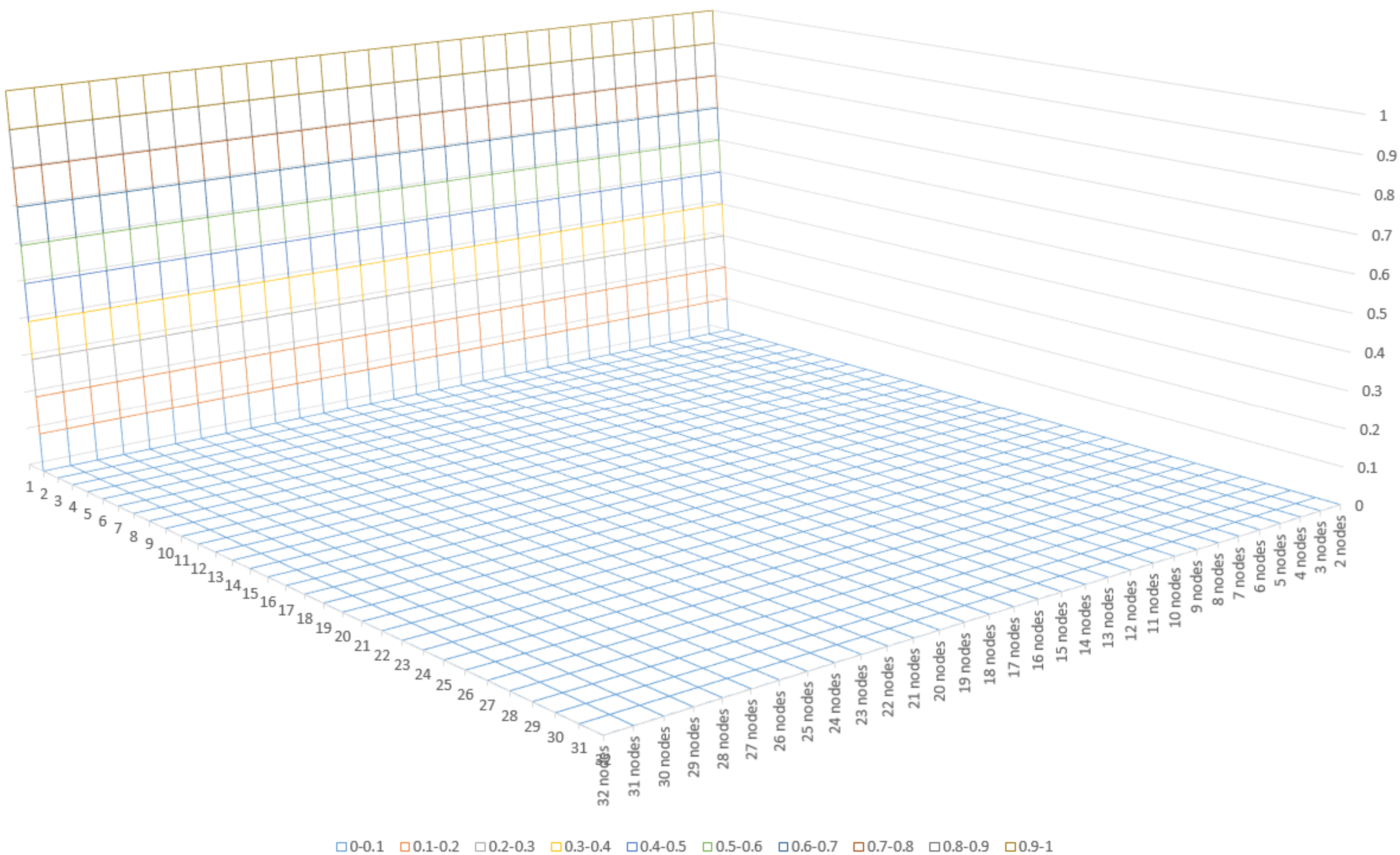
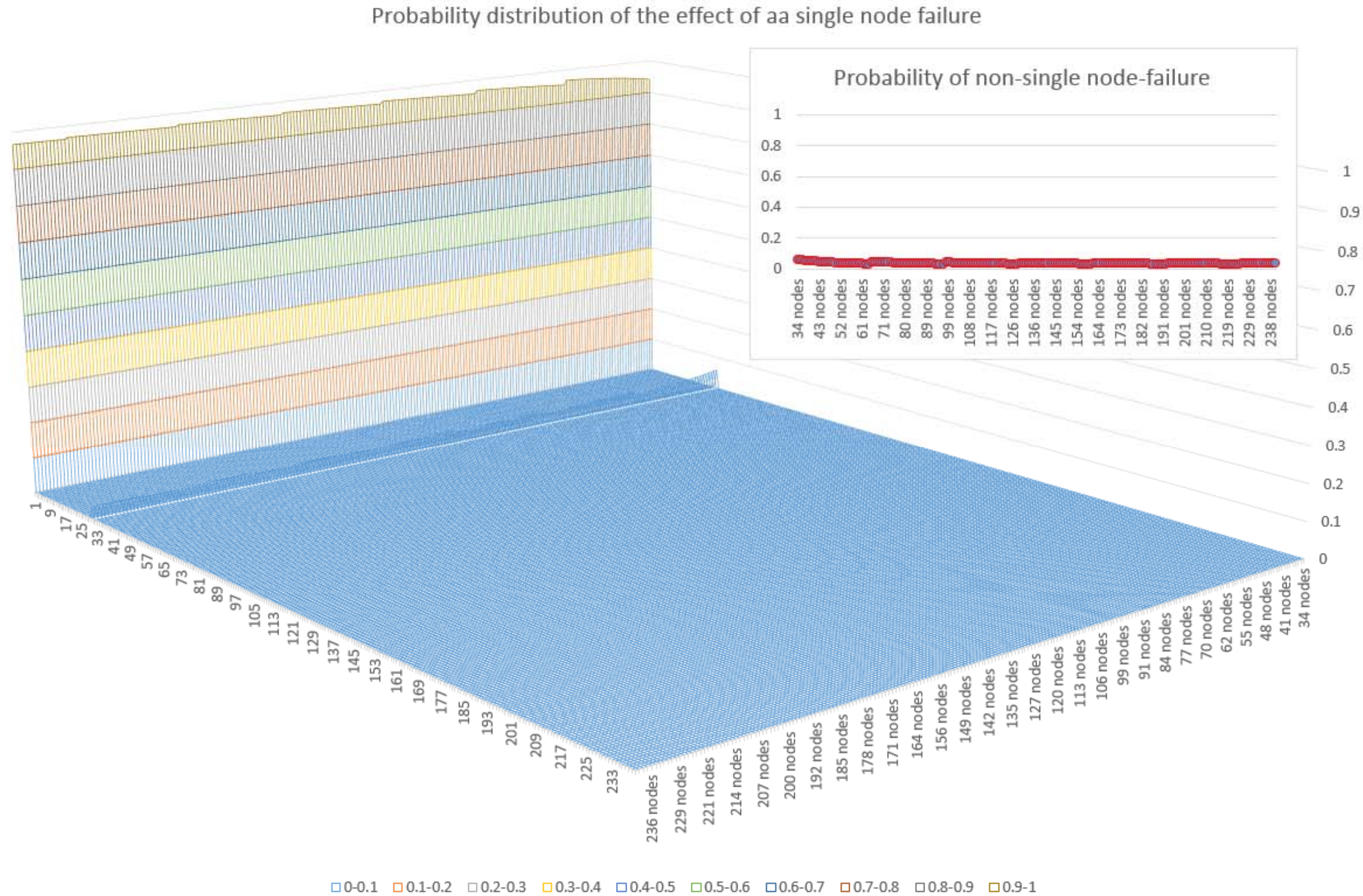


2-level multidrop bus



Interpretation

In these specific networks (topology) and under the above-mentioned conditions, multidrop seems to have more graceful degradation (loss of functionality) when nodes randomly fail

Thank you for your kind attention

Ari Kattainen
Gergely Huszak