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Strategies and Techniques for Ensuring Network Reliability for Enterprise Customers

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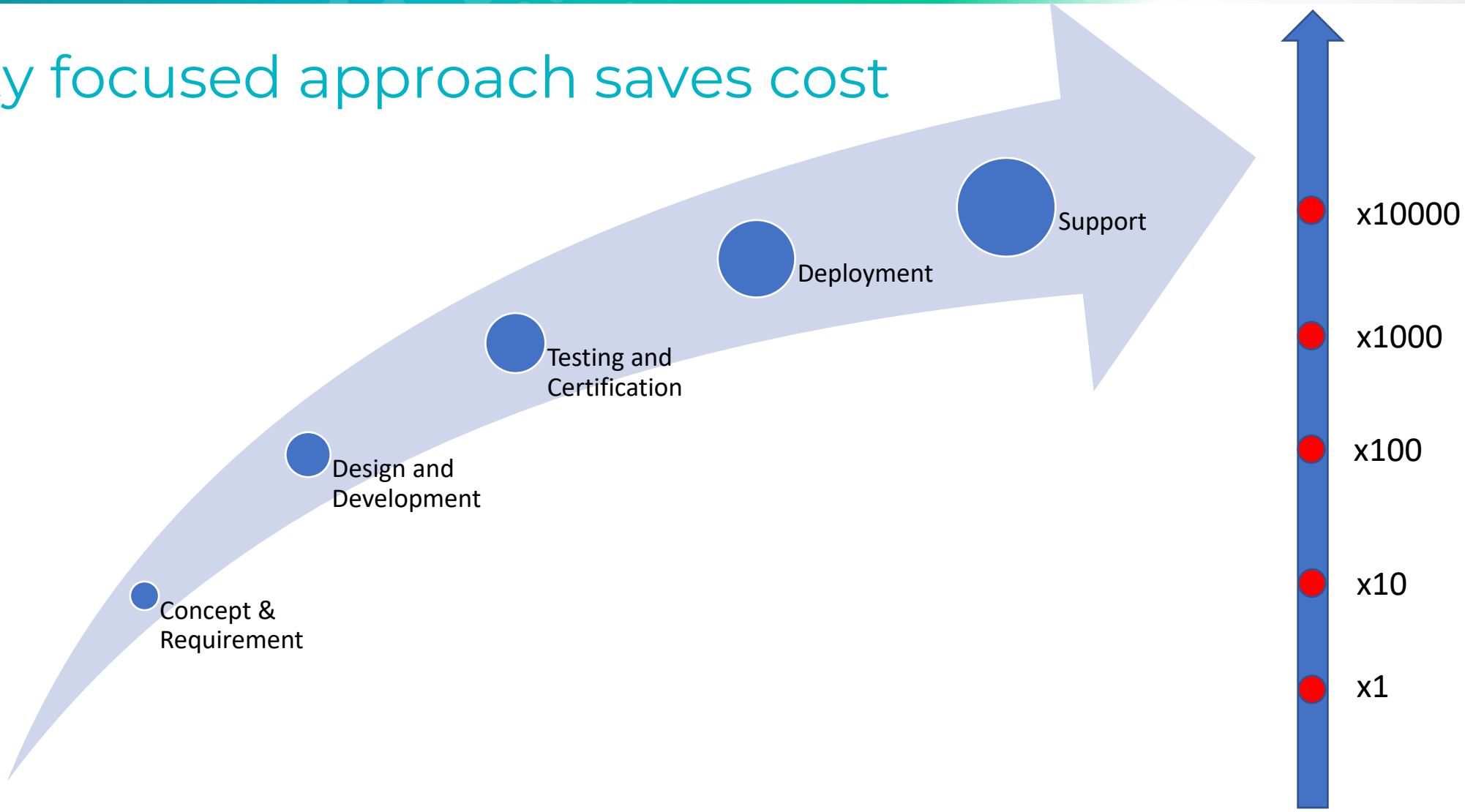
Best Definition

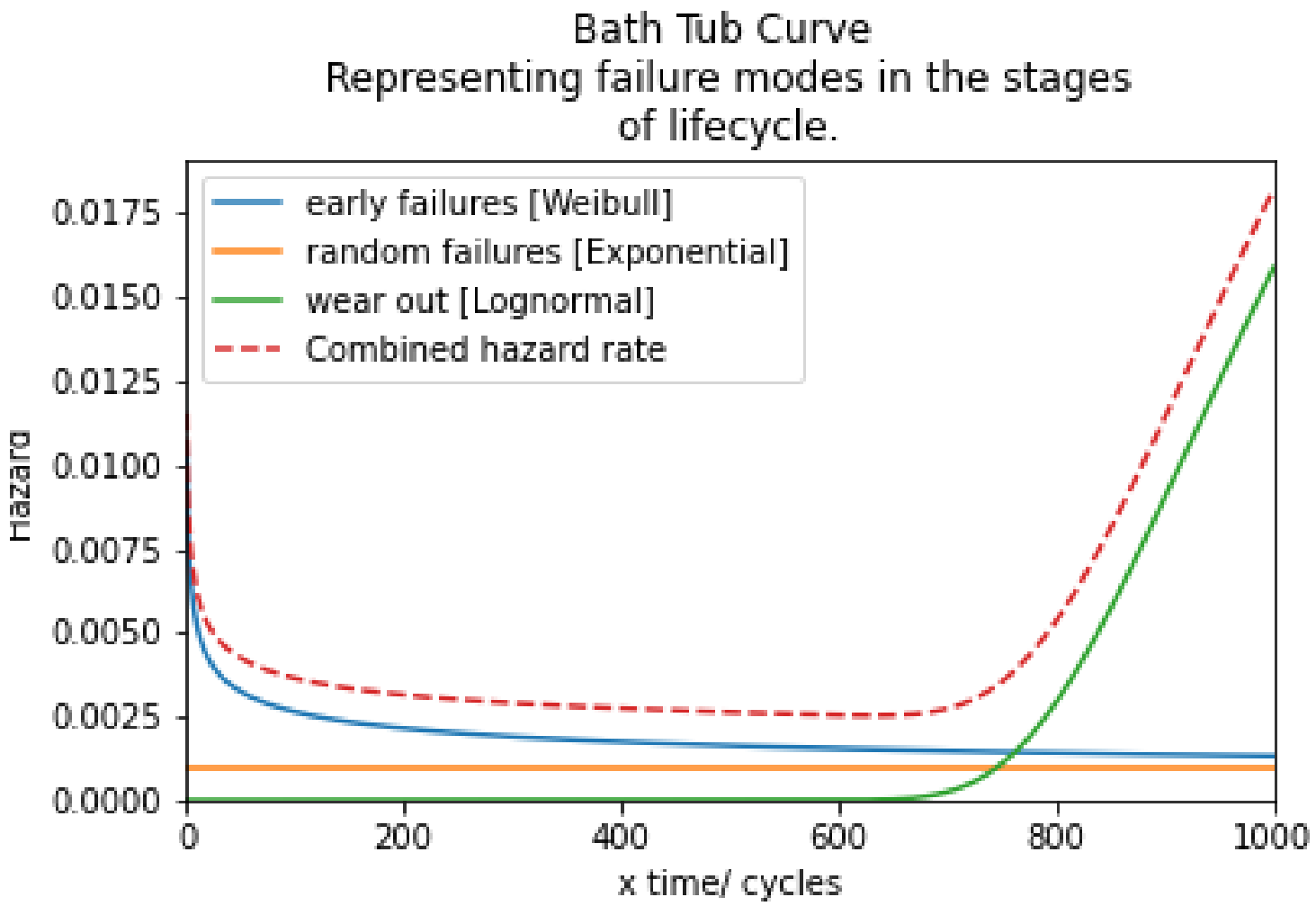
"The Reliability of an item (a component, a complex system, a computer program or a human being) is defined as the probability of performing its purpose adequately for the period of time intended under the operating and environmental conditions encountered."

Reliability focused approach saves cost



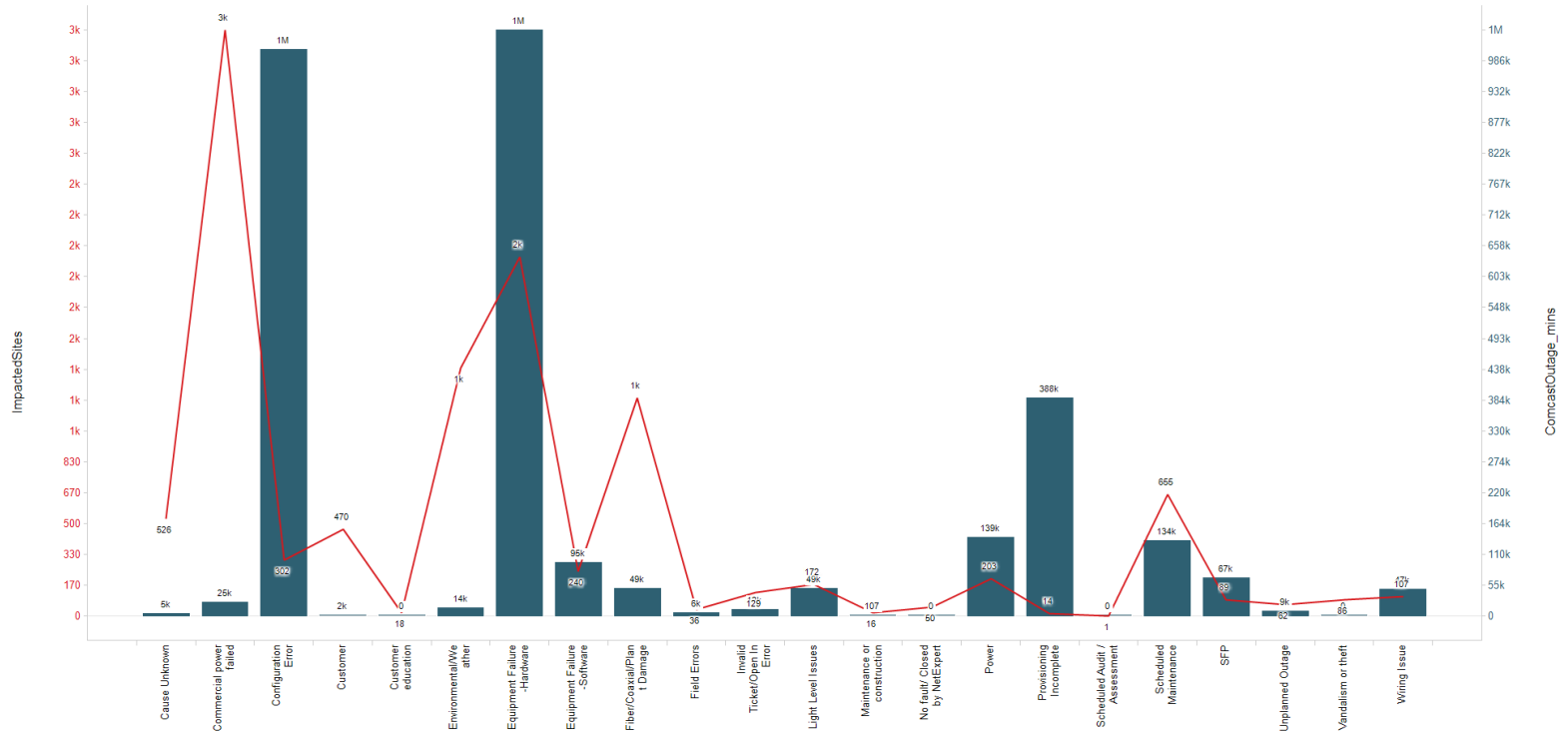
Bathtub Model

- Early Failures
- Chance Failures
- Wear Out Failures



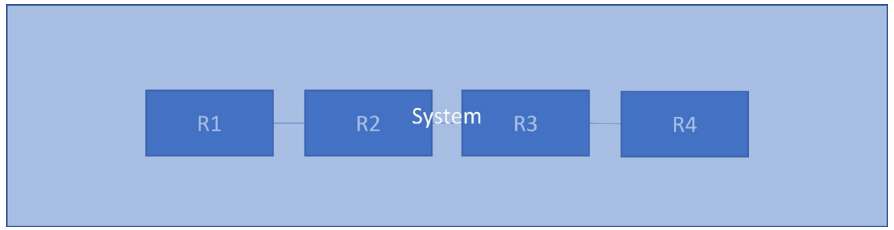
Example Failure Categories

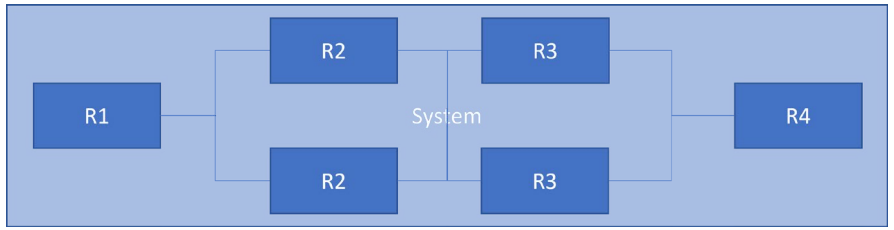
- Power
- Scheduled Maintenance
- Provisioning Incomplete
- Light Level Issues
- Hardware Failures
- Configuration Error

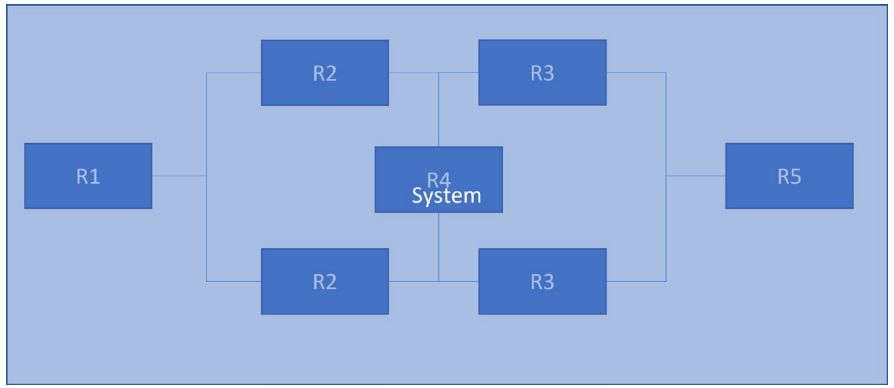


Basic Network Architectures

- Series
- Series Parallel
- Non-Series Parallel







Example of a Non-Series Parallel Network

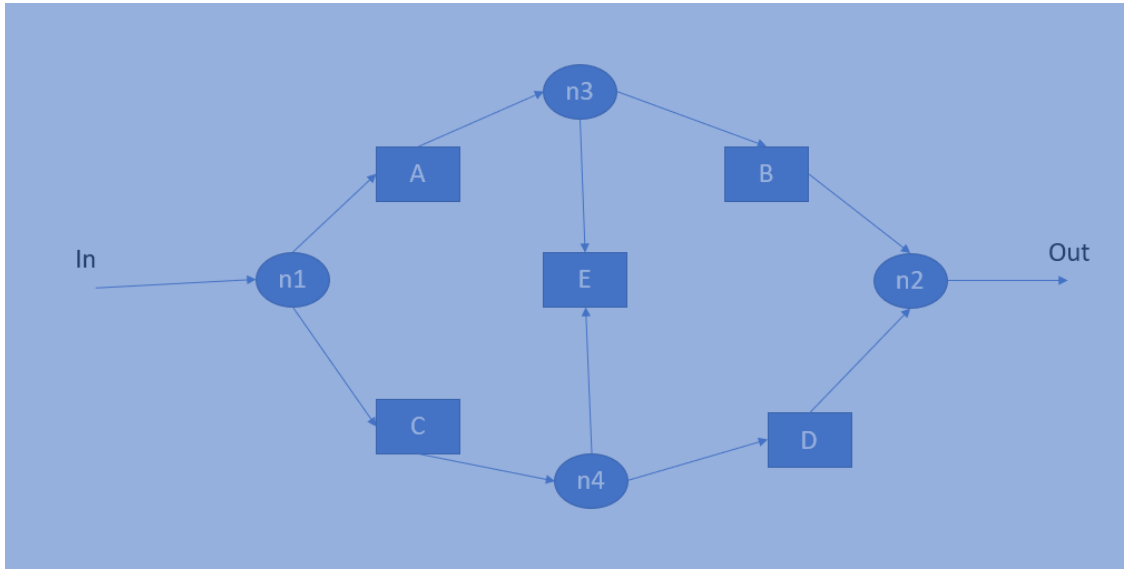
Assumption:

1. Edges Failure/Success are statistically independent
2. Nodes are perfectly reliable

Let p_a, p_b, p_c, p_d, p_e be success Probabilities of Edges A,B,C,D,E respectively

Also, q_a, q_b, q_c, q_d, q_e be failure Probabilities of Edges A,B,C,D,E respectively

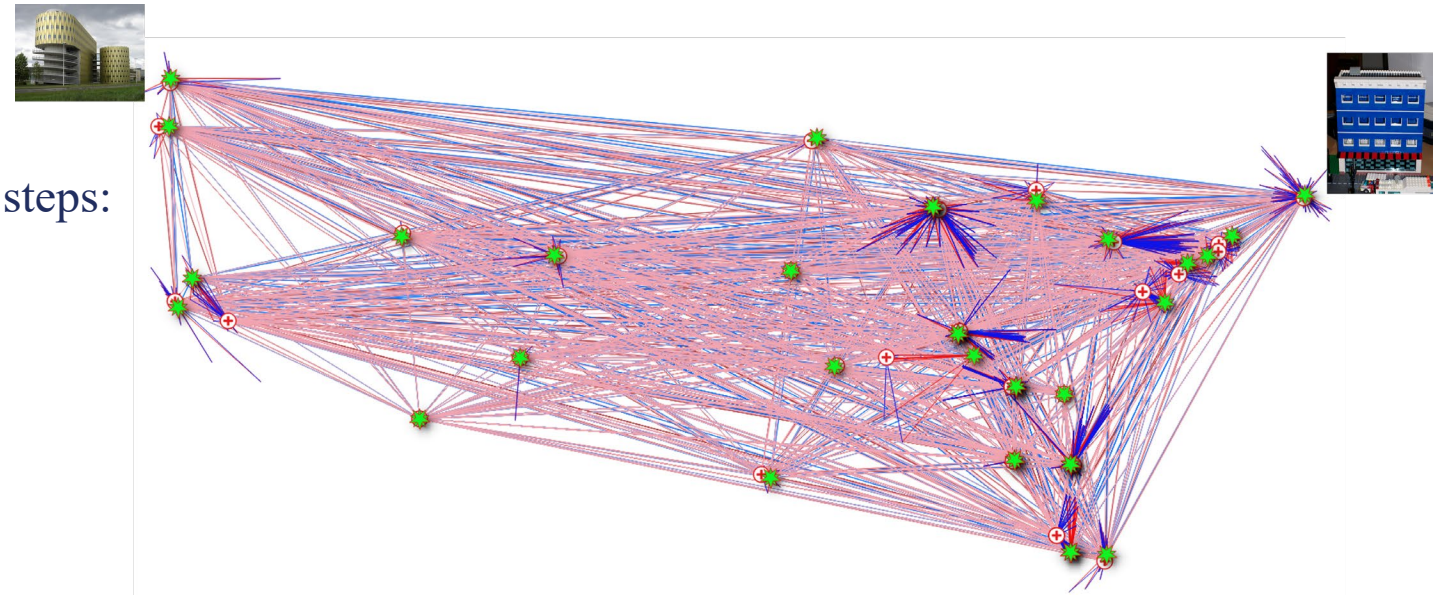
Then, R(Z) = $p_a p_b + p_a p_c q_b p_d$



Reliability Evaluation of Large Network

Programmatically the reliability of P2P links in a large network can be evaluated by following 3 steps:

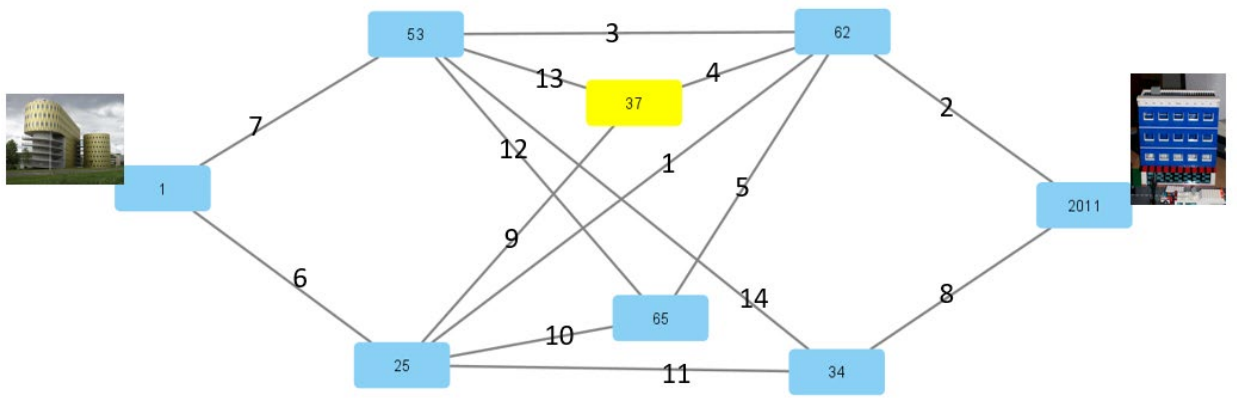
1. Create reduced network topology
2. Extract path set or cut set from the topology
3. Evaluate reliability from the path set or cut set extracted from step 2 using SDP and MVI



Step 1 Create reduced network topology

The goal of this step is to reduce the size of network. First select only those paths that are having E2E latency below Service Level Objective /Agreement. After retrieving the mentioned paths, merge them to create a new subgraph.

The resulting network graph is illustrated.



Step 2 Extract path set or cut set from the topology

There are two methods available :

1. Evaluate Path Sets
2. Evaluate Cut Sets

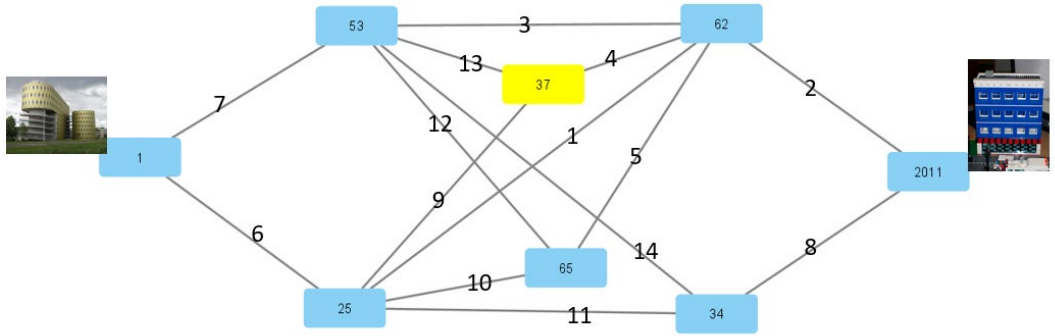
The decision logic is based on following formula:

For n – nodes and l - edges

- No. of Cut Sets = 2^{n-2}
- No. of Path Sets = 2^{l-n+2}

Select the method with least number

Finally enumerate Cut Set/ Path Set



CutSets		
2 8	1 7 8 9 10 14	1 5 7 8 9 12 14
6 7	2 3 7 11 12 13	2 3 4 7 9 11 12
2 11 14	3 4 6 9 12 14	2 3 5 7 10 11 13
1 3 4 5 8	3 5 6 10 13 14	3 4 5 6 9 10 14
1 7 9 10 11	3 6 8 11 12 13	3 4 6 8 9 11 12
3 6 12 13 14	1 2 4 6 10 13 14	3 5 6 8 10 11 13
1 2 6 9 10 14	1 2 5 6 9 12 14	1 2 4 5 6 12 13 14
1 3 4 5 11 14	1 3 4 10 11 12 14	1 3 9 10 11 12 13 14
1 3 4 8 10 12	1 3 5 9 11 13 14	1 4 5 7 8 12 13 14
1 3 5 8 9 13	1 3 8 9 10 12 13	2 3 4 5 7 9 10 11
1 4 7 10 11 13	1 4 5 7 11 12 13	3 4 5 6 8 9 10 11
1 5 7 9 11 12	1 4 7 8 10 13 14	

Step 3 Evaluate reliability from the path set or cut set extracted from Step 2 using SDP and MVI

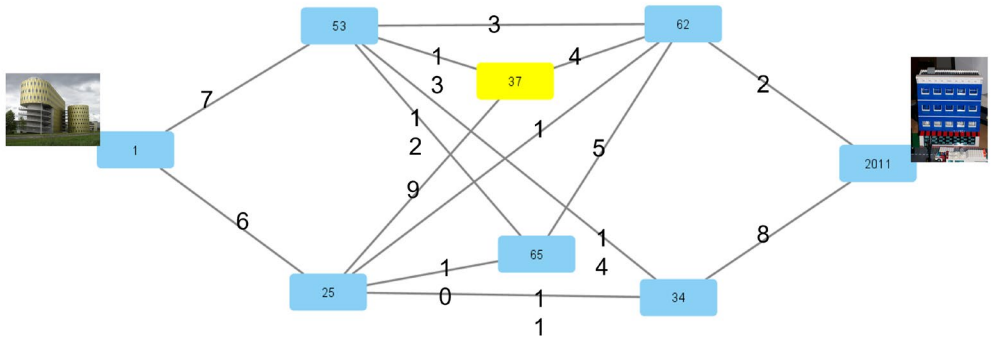
Finally, we can now evaluate reliability of the network by using CAREL algorithm (*Soh, S. & Rai, S., 1991).* The input that mentioned algorithms needed are cut sets and failure probability of the link. We assumed that all links fail with 0.1 probability.

The calculated reliability/unreliability of the mentioned P2P links is following:

System Unreliability = 0.02082693568

System Reliability = 0.979173064

With total disjoint paths = 76

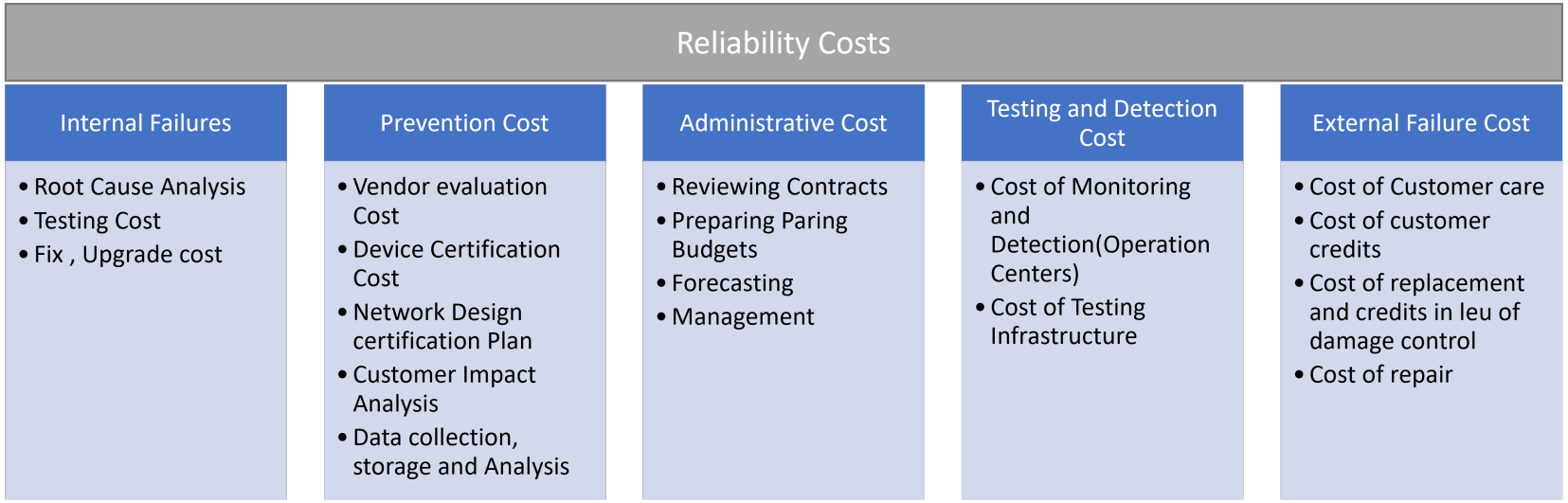


Some significant reliability cost contributors

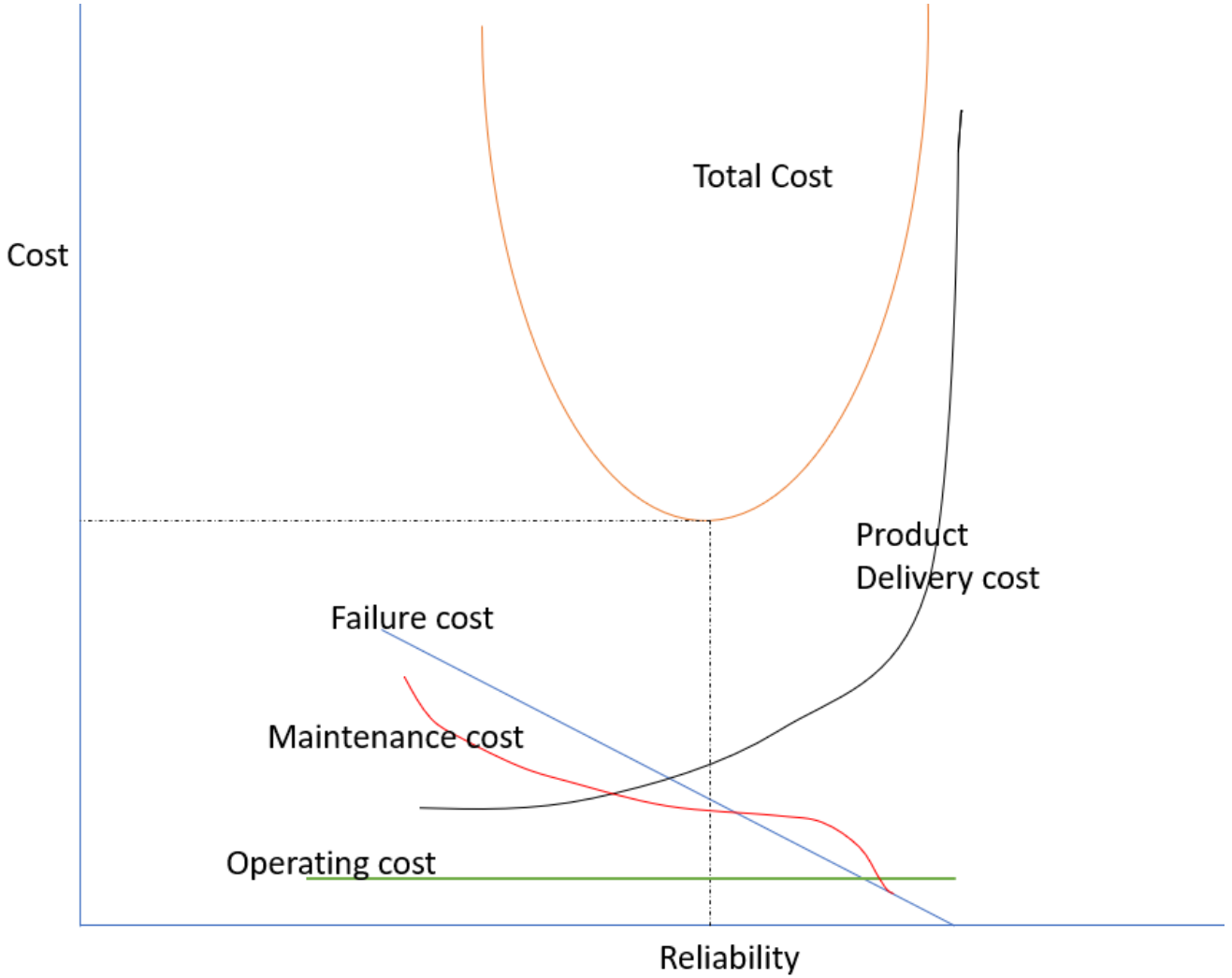
Managing reliability is a balancing act between the product / service perfection and cost of the product / service.

Each one of the categories on the picture contributes to the cost of attainment of a given reliability.

Cost vs reliability curve in the next slide will highlight the concept more clearly.



Cost vs Reliability Curves



A hypothetical scenario to demonstrate decision-making based on reliability

A hypothetical study is illustrated here on a model trained on real failures from a very large network. Here the goal is to showcase an optimum time at which the preventive maintenance shall be done on the devices given the **cost of preventive maintenance is 5** and **cost of corrective maintenance is 200**.

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Cost model assuming as good as new replacement (q=0):
The minimum cost per unit time is 0.0092
The optimal replacement time is 1095.22
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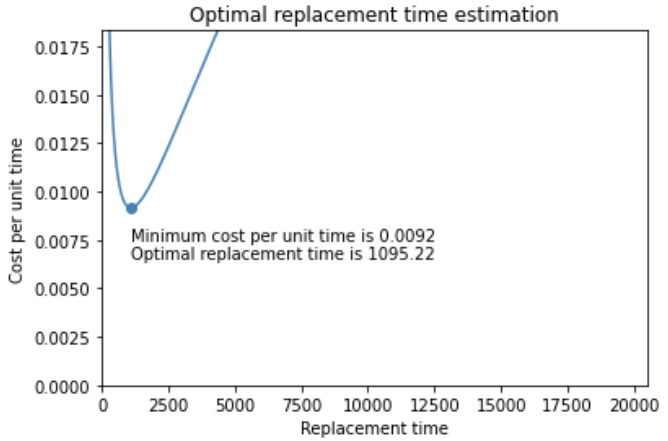

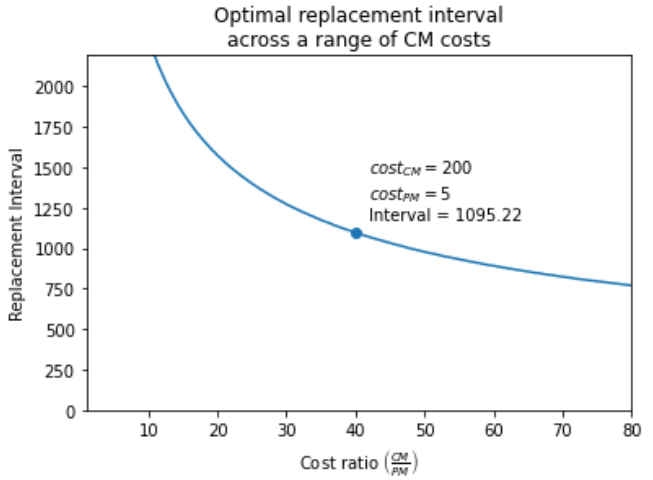

Summary

In this presentation we have covered the following:

- Definition of Reliability
- Benefit of Reliability when analyzed at every stage
- Three types of failure at different stages in the lifecycle of components
- We talked about example of categories of failures in a Network where different organizations, processes and skill sets can work together to achieve common Reliability goal
- We touched upon Reliability Evaluations in terms of different Architectures
- We discussed about evaluation of reliability of Large Network . Also, added an enhancement of reducing Computation by extracting k – Shortest Paths between two points and then reconstructing the Network Graph.
- Finally, we discussed about the Cost Optimization opportunities in Reliability

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Thank You!

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