Network Complexity

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RIPE-61
16 Nov 2010, Rome, IT
Intuitively, Network Complexity is Increasing …

Things tend to grow

… but, what is “Network Complexity”?
You Need Complexity (at least some)

Robustness requires some complexity
Tradeoffs and Complexity

expensive

Adding gratuitous complexity

optimization

Solution

Curve of optimal complexity

unscalable

Source: John Doyle
Elements To Consider: “State”

The “Complexity Cube”

Survey on Network Complexity

- Link sent to RIPE-list on 9 Nov 2010
- 64 Responses
- Profile of people who filled in the survey:

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 10</td>
<td>76.6%</td>
<td>49</td>
</tr>
<tr>
<td>5-10</td>
<td>17.2%</td>
<td>11</td>
</tr>
<tr>
<td>Less than 5</td>
<td>1.6%</td>
<td>1</td>
</tr>
<tr>
<td>I’m not in operations</td>
<td>4.7%</td>
<td>3</td>
</tr>
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Have you experienced “catastrophic failure” in your network?

NO (2)

YES (62)

Source: Survey for RIPE-61, presented on 16 Nov 2010 in Rome (panel on network complexity)
If yes, what was the cause of this catastrophic failure?

- Complexity: 0.0%
- Bug in the vendor equipment: 40.0%
- Operational mistake: 80.0%
How likely do you think that over the next 5 years your network is going to experience a catastrophic failure?

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<tbody>
<tr>
<td>Pretty likely</td>
<td>20.3%</td>
<td>13</td>
</tr>
<tr>
<td>Possible</td>
<td>56.3%</td>
<td>36</td>
</tr>
<tr>
<td>Unlikely</td>
<td>23.4%</td>
<td>15</td>
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How often do you encounter network problems that can only be resolved by the top experts in my organisation?

- Rarely: 31.3% (20)
- Sometimes: 56.3% (36)
- Frequently: 12.5% (8)
Where is the origin of complexity in your network *mainly* located?

![Bar chart showing the distribution of complexity origins.]

- Other... 10.0%
- The... 10.0%
- The... 10.0%
- Network... 5.0%
- Router /... 30.0%
- Router /... 10.0%
- The... 5.0%
Other...

ESX running with different vendors, e.g. HP c7000 and IBM BladeCenter H. All with Hypervisor(x) running, different network vendors like (BNT)BladeNetworks on IBM+Emulex+QLogic - Brocade, Cisco etc on HP c7000, linking up to e.g Nexus 50xx platform on 10Gbps. VM’s and the infrastructure from host to end link, many components are involved and many different BIOS/Firmware version on these. Any poor code in just one of these vendor components can result in a catastrophic failure up to the CORE. We have already expired this.

Lack of documentation, cable labelling etc

High volume of devices. Complex topology.

The unnecessary grafts added by various complications departments without regard for architectural elegance and simplicity.

Router configurations, Human operator, design, boss requirement

Multiple conflicting customer requirements

Both physical cause, operator mistakes and buggy behaviour in router software.

A combination of the above as, for example, an "e2e" IP service requires 3 layers and a number of different technology hops.

multi vendor scenario
Your Definitions of “Network Complexity”

The number of elements within a network and the associated loss of determinism in predicting network behaviour. Not easy to manage, not easily adaptable to changes.

Hardness in documentating relations between physical equipment, logical entities and operating procedures. From virtual host - towards the ISP at last. The complexity is from the VM's hardware link which now also is virtual configured - towards shared 10Gbps links in the hardware enclosure (sometimes up to 3 components) before it is linked to the distribution switch level and then the CORE. Cloud business is demanding more of this, which again makes it all more complex in the internal cloud infrastructure.

Network complexity means that the network depends on so much interdependent factors that changes apparently safe end up affecting seriously the network operation. Often we have to re-invent the wheel.

Set of configurations, technologies and designs that make a network difficult to operate for the assigned people in a company. Complexity can be solved with more training for example.

Variety in the elements of the network

The degree in which a network does not have a clear and straightforward design, and where consequences from a component failure cannot easily be understood through logical deduction.

High number of elements running a large number of processes, with a loose level of synchronization between them (aka, a non-linear combination of processes in a N-order connected topology).

Too many features in use.

Poorly designed networks, legacy and non-legacy networks interaction, networks built with one solution in mind being extended to fit other roles (poorly). Non automated provisioning leading to frequent human errors. Lack of knowledge within Network Operations leads to bad operating decisions.

ISP, complex networks

1) All things added by the complications departments. ;)
2) All things that have the potential to make the network behave in very unexpected ways; these are mostly of the 'wrong assumption' kind. ;-(

the design of the network and the services running over them... then new service comming and redesign it's needed <=> network complexity

An accumulation of 'special cases', deviations from a previously consistent architecture, which have to be taken into account for each new add/modify/remove to the design.

That which makes the network harder to completely grok.

Advanced configuration and complex routing scheme

Complex routing scheme combined with lots of nodes in the topology, a bad network :p

In this survey the definition of network complexity is based on the network that: makes it non-trivial to predict how traffic moves when an error of any kind occurs makes it non-trivial to understand why traffic flows the way it flows involves several protocols

The end-to-end combination of technologies and planes required to deliver network services.

Too many different protocols that all need to operate correctly to make the system work - too many interdependencies, hard to figure out where a given problem is originating from.

Poorly documented

The number of variables dependent on each other in a given architecture (pieces of hardware, number of OSes, difficulty of configuration, result target, workarounds, etc). (This is certainly not the only definition.)

Inconsistent configs

Multi-vendor environment with challenges

Ad-hoc networks.

Amount of machines involved in the network, routing levels, sub netting, etc.

Stuff that can break in non-obvious ways
The Panel

• Geoff Huston
• Nico Fischbach
• Gert Döring
• Michael Behringer
Questions

• Examples of “catastrophic failure”: What caused the root failure?
• What makes your network complex?
• How do you contain / control complexity?

• Wiki: http://networkcomplexity.org
  (please contribute!)