Inter-X: Resilience of the Internet Interconnection Ecosystem

The Internet connects a large number of independent networks. Those networks cooperate to ensure that each network's users can reach every other network's users – directly or, most of the time, indirectly. The Internet interconnection system is the system of direct and indirect connections between networks that is the essence of the Internet.

The resilience of this system is important to us all. It clearly depends on the resilience of the component networks, and the direct connections between those networks. Obviously, it depends more on the resilience of larger networks, particularly those who provide services to smaller ones.

Is the Interconnection Ecosystem Resilient?

This study is interested in the resilience of the ecosystem, looking at:

- ✓ its response to events with medium to high impact and medium to low probability
- ✓ how that resilience may be assured and improved.
- ✓ what may influence that resilience in the long term.

Particularly from a European perspective but, as with anything to do with the Internet, the context is clearly global. This requires the study to consider the nature of the ecosystem and how its resilience may be assessed.

The objective of the study is to examine and describe the issues, and to make recommendations to address those issues. The study is constructing a "State of the Art" report, based on review of the available research and literature, and on a consultation involving researchers, regulatory bodies and industry practitioners. The consultation involved a short questionnaire and some follow-up telephone conversations.

Issues Raised

The Internet Interconnection Ecosystem is made up of the many bilateral arrangements between networks. These arrangements are all independent of each other, there is **no central coordination or control**. Also, the nature, the number, the capacity and the traffic load of connections between networks are unknown. Much of the information required is deemed commercially sensitive, and is hidden.

While the ecosystem is tested daily by small scale failures, and occasionally by larger incidents, because there is no body responsible to gather and analyse the ecosystem level information about the failures, the root causes, the true effects, the lessons to be learned etc. Even worse the likely redistribution of traffic between connections and networks, and the probability of creating congestion in the event of **a large scale failure**, are unknown.

Resilience is not a straightforward matter, and a **measure for degrees of resilience** is conspicuous by its absence.

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The sheer scale of the ecosystem means that, on the one hand it is hard to imagine any event that could have a major **impact across the entire system**, while on the other hand it also means that an event that affects, say, 10% of the system is an event that affects a lot of people. It is not known what sorts of real-world events will have a significant impact on a significant proportion of the system.

The system appears both **robust and fragile at the same time**, because most events cause local and/or short term problems. Major routing failures are often cleared up in hours. Large losses of capacity (loss of undersea cables, for example) are worked around in days, and repaired in weeks.

Altogether trivial software and/or human errors regularly cause wide scale disruption –though, as noted above, usually only for a few hours.

Finally, the overall system of **incentives** that drives the ecosystem and the tendency in the transit market towards **lower prices** does not appear to work to improve resilience of the ecosystem.

The Results so Far

The resilience of the Interconnection ecosystem has been given very little attention – the "invisible hand" has created the interconnection ecosystem, and it is easy to assume that it will continue to work as well as it does (despite the fact that there is no way to assess how it would react to this or that major event). This study aims to reveal the issues and suggest ways forward.

Tentative conclusions include:

- ✓ there is a shortage of data on almost every aspect of the system.
- ✓ there is no systematic monitoring of the system.
- ✓ there is no thorough and authoritative analysis of events which affect the system.
- ✓ there is no good measure for resilience, in its various forms.
- ✓ the state of the transit market, the incentives which may improve or reduce resilience are not well understood.

Next steps

A consultation on the final report, including a Workshop, is planned as an immediate next step in early 2011 (http://www.enisa.europa.eu/publications/studies).

ENISA also plans to take on board some of the recommendations and continue working in this area further within 2011. The topics that will be covered include: economic incentives, Service Level Agreements, peering arrangements, ecosystem monitoring, data collection, assessment and traffic engineering.

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