Innovative R&D by NTT

Network Disaster Management and Recovery

March 16, 2016

NTT Network Technology Laboratories

Hiroshi Saito

History of damages to NTT networks

Innovative R&D by NTT

Year	Disaster	Countermeasures
1968	Earthquake	Making two routes for inter-city transmission system. Development of wireless system.
1978	Earthquake	Reinforcing floors of network building and ducts at bridges
1982	Heavy rain	Developing long life battery and increasing num. of power generators
1983	Heavy rain	Developing satellite system for disasters and portable switches
1990	Heavy rain	Developing portable wireless units
1993	Earthquake	Developing portable satellite terrestrial station
1995	Earthquake	Developing Disaster Emergency Message Dial (DEMD)
2007	Earthquake	Distributing portable power supply systems
2010	Heavy rain	Introducing Broadband DEMD

Damage from tsunami as result of 2011 earthquake

[source] Keynote speech by Ryuji Yamada, DOCOMO's Actions for New Growth, ICC2011, Kyoto.

Panel, DRCN 2016, Paris, France.

Network damage (NTT Group networks)

- 1.5 million circuits for fixed-line services damaged
- 6,700 pieces of mobile base-station equipment damaged
- 15,000 circuits for corporate data communication services damaged
- 90 transmission line routes disconnected
- 18 exchange office buildings destroyed
- 23 buildings submerged
- 65,000 telephone poles destroyed
- 6,300 kilometers of aerial cable damaged

History of large earthquakes after ‘90

Innovative R&D by NTT

Japan

2011 East Japan

1995 Hanshin-Awaji

World

2010 Haiti

2008 Sichuan, China

2005 Kashmir, Pakistan (India)

2004 Sumatra, Indian Ocean

Increase in disasters worldwide

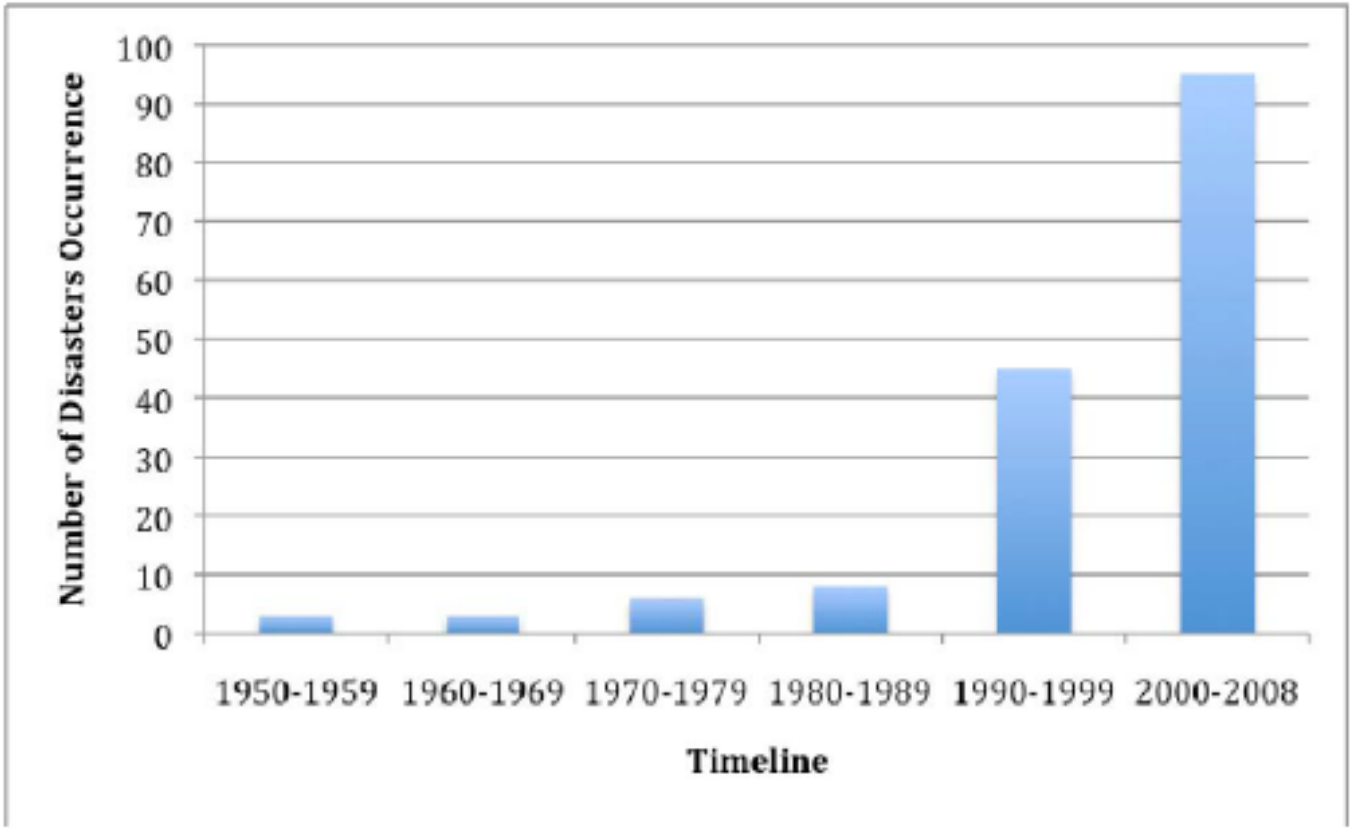


Figure 1. Evidence of Increasing Disasters on a Worldwide Scale

(source: E. Asimakopoulou, N. Bessis, S. Sotiriadis, F. Xhafa, and L. Barolli, A Collective Intelligence Resource Management Dynamic Approach for Disaster Management: A Density Survey of Disasters Occurrence, IEEE INCoS, pp. 735 - 740, 2011.)

NTT Group basic policy on disaster countermeasures

Innovative R&D by NTT

1. Improving network reliability
   - Multiple transmission routes
   - Distributed locations of important network facilities
   - Disaster resistant network facilities
2. Securing critical communications
3. Promptly restoring communication services
   - Portable power supply vehicles
   - Portable terrestrial stations for satellite communications

http://www.ntt.co.jp/saitai/en/3principles.html

“protection + restoration”

New approach

Innovative R&D by NTT

New approach to disaster management

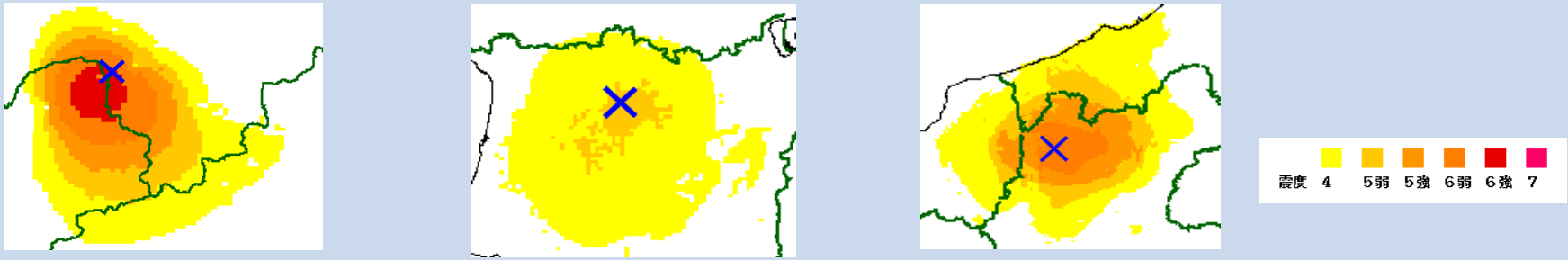
- network design to minimize probability of encountering disasters (mainly for earthquakes)
- network control to avoid dynamically forecasted disasters (mainly for typhoons and heavy rains)

Disaster-free Network

Principle of disaster-free network

Innovative R&D by NTT

Disaster is a spatial and geographical event



Network damage can differ depending on relative locations between the network and the disaster area.

⇒ Introduce an assumption describing the location of the disaster area and evaluate a metric (M) regarding network damage.

⇒ M is a function of geographical network characteristics.

⇒ Find optimal characteristics regarding M!!!

Summary of design and control

	Network design		Disaster avoidance cont.
Disaster	Earthquake		Typhoon, heavy rain, tsunami
Assump.	Random	Possible seismic locations	Highly possible forecast
Applica. and Objec.	Geographical/spatial design of physical and logical network. Earthquake resistant network update planning.		Geographical/spatial redesign of logical network
Backgro und	Data accumu. on earthquake damage	Advancements in earthquake seismology. Data accumulation on earthquake damage.	Advancements in meteorology. Software oriented network implementation.

Example: optimal server placement

Logical Network Design

Assumption:

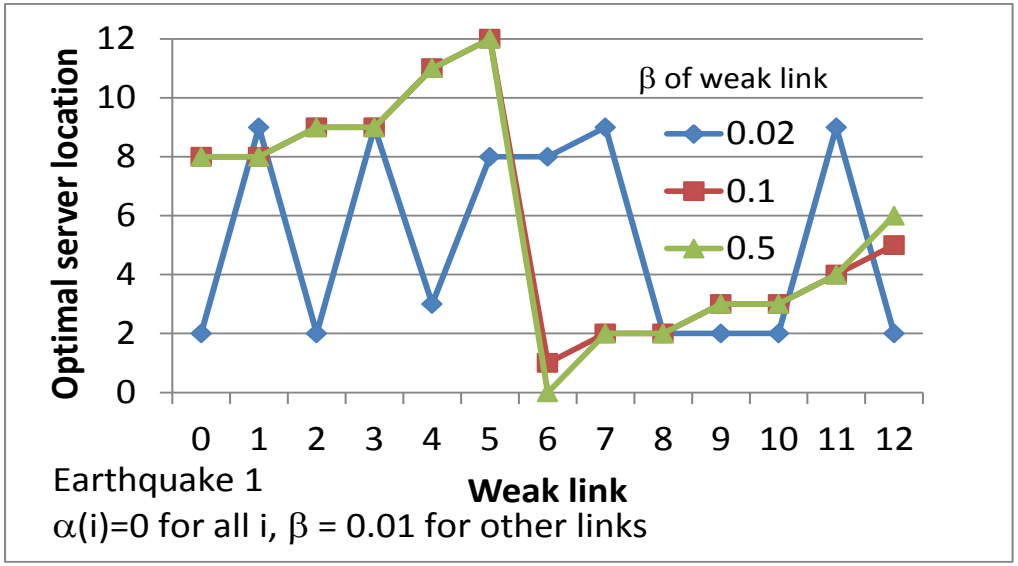
Random disaster occurrence

Optimization:

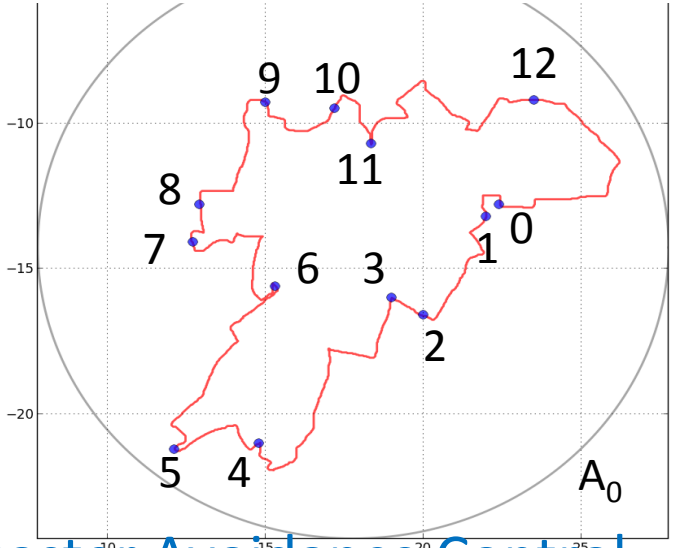
Determine a server placement s*

s* = argmin_s max_t Pr(disconnection between s and t)

Result of network design (one weak physical link case)



Disaster-free network design can determine the geographical route of this network.



Disaster Avoidance Control

Assumption:

Forecasted disaster occurrence

Optimization:

Among server nodes, determine a server node that needs to be evacuated.

H. Saito, Spatial Design of Physical Network Robust against Earthquakes, IEEE Journal of Lightwave Technology, 33, 2, pp.443-458, 2015.

Conclusion

- Proposed a network concept called “Disaster-free Network” and its implementation methods “Network Design” and “Network Avoidance Control”
- Unique achievement: avoid or minimize encountering disasters

Related works

Surveys of disaster management

- B. Mukherjee et al., IEEE COMMAG, 2014.
- M. F. Habib et al., Comouter Communications, 2013.
- E. Asimakopoulou et al., IEEE INCoS, 2011.

Network damage due to earthquake

- Y. Ran, IEEE COMMAG, 2011.
- M. Kobayashi, IEEE COMMAG, 2014.

Disaster-free Network

- Hiroshi Saito, INFOCOM, 2014.
- Hiroshi Saito, IEEE Trans. Networking, 2015.
- Hiroshi Saito, IEEE J. of Lightwave Technology, 2015.
- Hiroshi Saito et al., Networks 2014.
- Hiroshi Saito, DRCN 2015.

Network survivability under spatial/geographical conditions

- S. Neumayer and E. Modiano, INFOCOM, 2010.
- W. Wu et al., WAINA, 2009.
- C. Cao et al., IEEE J. Lightwave Technology, 2013.
- A. Sen et al., INFOCOM, 2006.
- M. T. Gardner and C. Beard, CQR, 2011.
- M. T. Gardner et al., DRCN, 2014.
- D. Bienstock, Math. Oper. Res., 1991.
- S. Neumayer et al., INFOCOM, 2012
- S. Neumayer et al., IEEE Trans. Networking, 2011.
- P. Agarwal et al., INFOCOM 2011.
- Y. Zhang et al., ICCT, 2012.
- S. Trajanovski et al., IEEE Trans. Networking, to appear.