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Developing Scientific Foundation for CIIP and Dependency Analysis: Questions for Discussion

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Issue

Are there “laws of nature” in cyberspace that can form the basis of scientific inquiry in the previous mentioned fields (i.e. Critical Information Infrastructure Protection)? *Are there mathematical abstractions or theoretical constructs that should be considered?*

I will discuss this issue by making reference to the Internet infrastructure

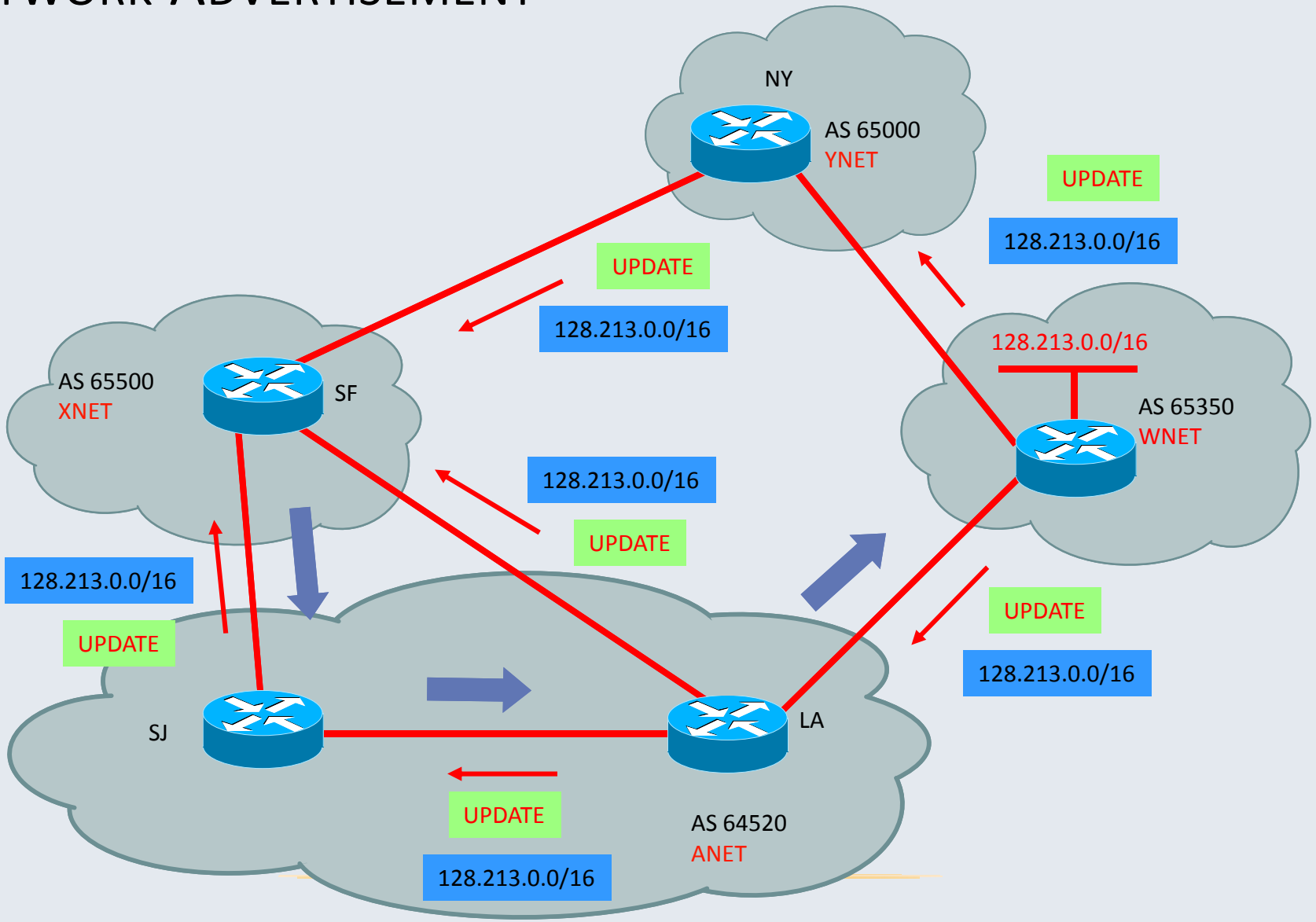
How is the Internet 'Glued' Together?

- ✓ Internet is currently partitioned into more than 40.000 Autonomous Systems (ASes) interconnected via the Border Gateway Protocol (BGP) which is a critical protocols for the Internet

- ✓ BGP was designed long before security became a serious issue for the Internet

BGP retains a number of vulnerabilities

Network Advertisement

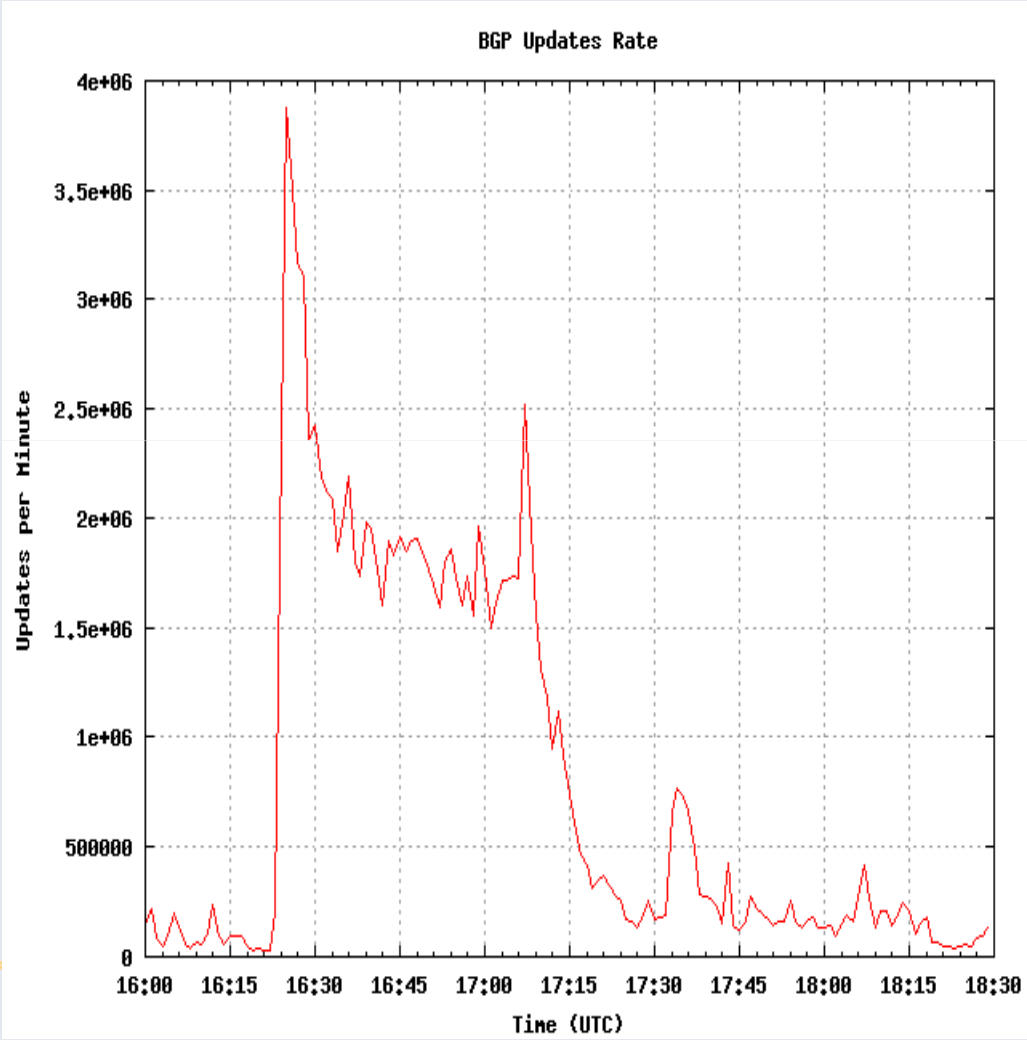


BGP Failures

- ✓ When BGP fails, portions of the Internet may become unusable, thus causing a loss of connectivity between critical portions of the Internet
- ✓ E-mail, e-commerce, and Web accesses would be put out of service for a period of time ranging from minutes to hours!
- ✓ BGP outages could be either
  - *- widespread, affecting large portions of the Internet (e.g. route flapping), or a*
  - *- targeted against a particular network (e.g. denial of service - DoS)*

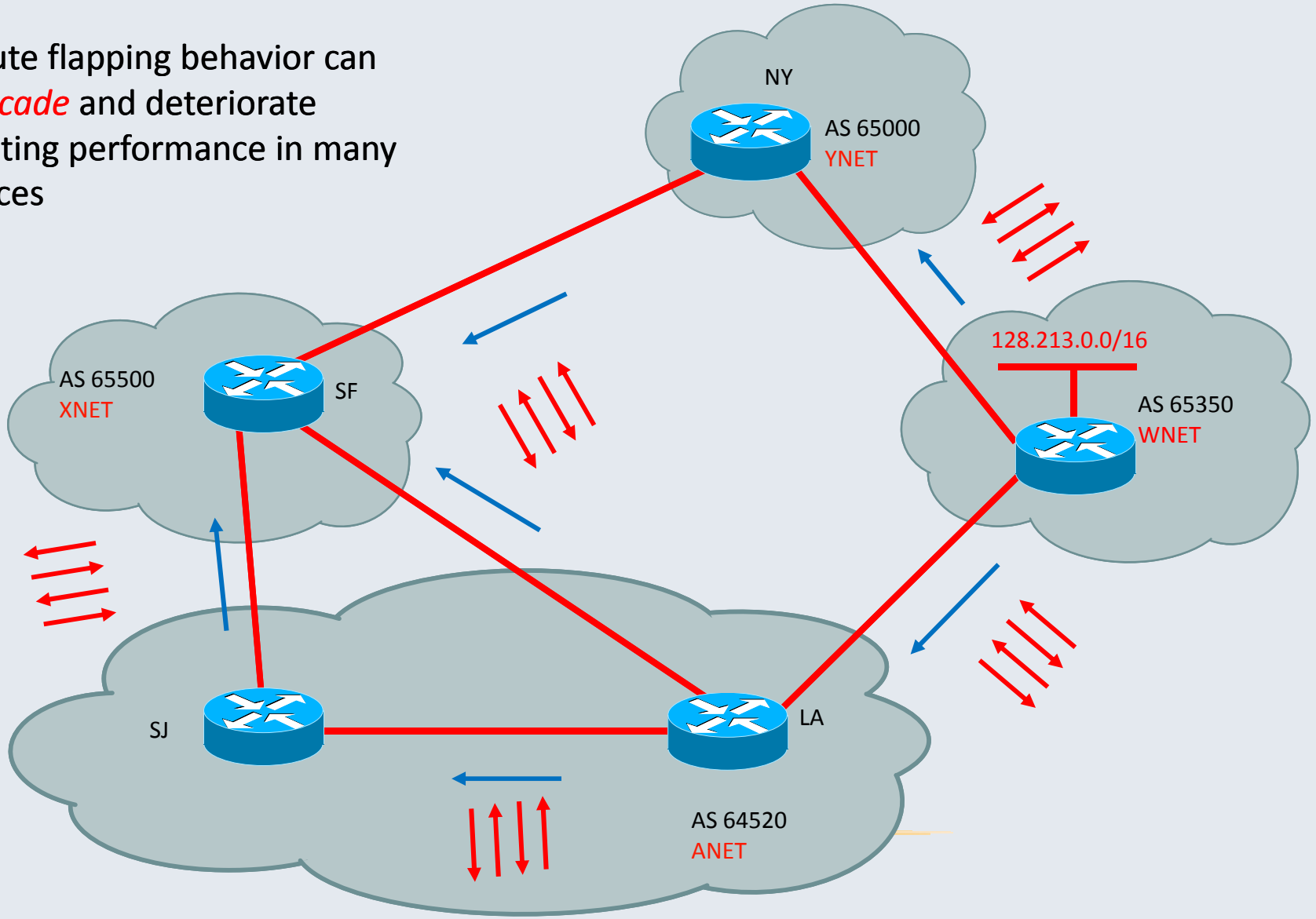
Route Instability

- ✓ *Route Flapping:* occurs when a previously advertised route is withdrawn and then re-announced repeatedly in a short period of time
- ✓ If route flaps happen fast enough the router becomes overloaded, eventually preventing convergence on valid routes



Route Flapping Without Dampening

Route flapping behavior can *cascade* and deteriorate routing performance in many places



Route Instability

- ✓ Route flapping can result in a denial of service (i.e. routers are flooded with more packets than they can handle)
- ✓ The route flap *damping* (RFD) has been designed to prevent routers from thrashing while trying to re-calculate a large number of BGP UPDATEs
- ✓ However, both measurement studies and operational observations show that BGP path exploration can trigger false route damping which leads to prolonged periods of lost network reachability
- ✓ As a result, many networks turned off RFD

Anecdotes of Route Flap Storms

- ✓ April 25, 1997 - small Virginia ISP injected incorrect map into global Internet. Map said Virginia ISP had optimal connectivity to all destinations. Everyone sent their traffic to this ISP. Result: shutdown of Tier-1 ISPs for 2 hours
- ✓ August 14, 199 - misconfigured database server forwarded all queries to ".net" to wrong server. Result: loss of connectivity to all .net servers for few hours
- ✓ More recent events causing route flapping are reported in the Renesys Blog
  - http://www.renesys.com/blog/2009/02/the-flap-heard-around-the-worl.shtml
  - http://www.renesys.com/blog/2010/08/house-of-cards.shtml#more

Best Common Practices at Work

- ✓ Comprehensive BGP security solutions have not yet emerged and current "best common practices" are somewhat
  - *overlapping,*
  - *confusing in scope and applicability, and often*
  - *neglect cost/benefit tradeoffs*

- ✓ Many researchers believe that the Internet may be so hopelessly broken that it could be better to start over, rather than continue to apply band-aids

Long Term Growth Trends in Internet Routing

- ✓ Question 1

  Will the previous problems be exacerbated when the Internet size increases, e.g. double in size?

- ✓ Question 2

  Will the routing system be able to scale and meet the growth of the Internet and its ever-expanding level of demands?

- ✓ Question 3

  What is the ability of the system to produce a stable view of the overall network topology?

Simulative Analysis

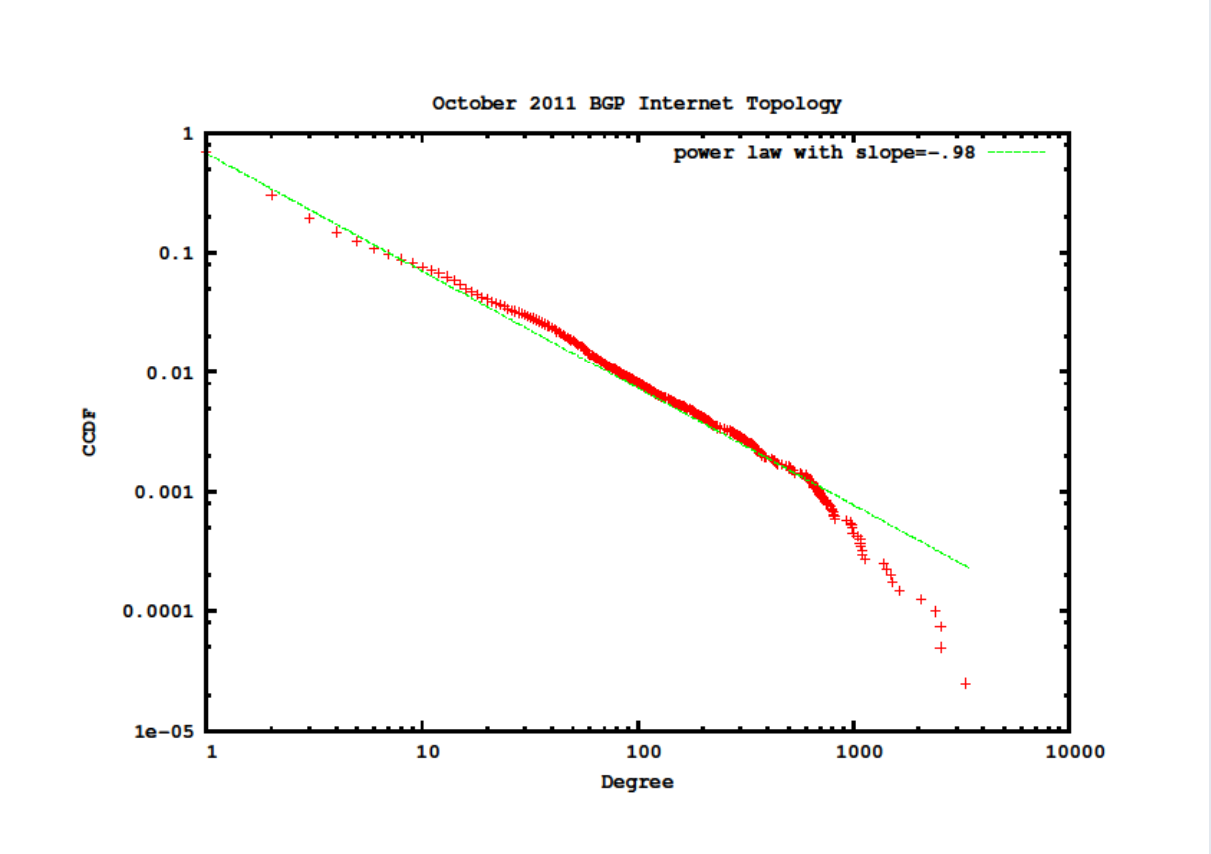
- ✓ We can use simulation to evaluate a proposed BGP security solution before deployment

BUT

this requires an *Internet AS-Level topology* model

Barabasi-Albert Model (Preferential Attachment)

The Barabasi-Albert model (green line) is not adequate to represent the Internet growth at the AS-level of abstraction



CONCLUSIONS

A new (more realistic) model is needed for getting robust results while simulating BGP securiry algorithms

Research is still underway