What should we learn from 25 years of the Internet:

A DNS case study

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What’s the Point?

- Four reasons:

  1. Just record the history
  2. Have a good party and talk about how we were geniuses (cue Bruce Springsteen, “Glory Days”)
  3. Learn principles for the future
  4. Make fun of the “clean slate”

- All have issues, let’s stick to #3.

Source: Nominum

Why a DNS case study?

- It’s my area of expertise
- Experts for other protocols often
  - Disagree about age of Internet
    - 40th birthday if you include ARPAnet
    - ~120th birthday if you think about Hertz/Marconi
    - Internet era may have ended with HTTP / web2.0
  - Get into credit food fights
  - Like the history or party idea better
- DNS has evolved by many hands
- DNS touches most of the rest anyway, so may be a good place to start

Source: Nominum

EarlyTimeline

- Nov 1983 – RFCs 882, 883
- 1985/1986 machines without host tables
- Jan 1986 – MX style mail routing
- Nov 1987 – RFC 1034, 1035
- Aug 1988 – “Development of the Domain Name System”, Sigcomm 88
  - AKA DoDNS

Source: Nominum

Then - 1983

- Previously, the IP/TCP transition meant that every system could be rethought
  - For example, FTP->FTP & separate email

- Many, many things to rethink
  - Important folks rethought what were seen as important issues, for instance
    - Routing
    - Card images in TCP
    - Design of “The Directory”
  - Less important folks did things like
    - DNS
    - Datagrams
  - Some things seemed simple
    - Managing & allocating names

Source: Nominum

Intent of DNS protocol design 1983

- Provide a design that was just lightweight enough to take off
- Provide a design that had orthogonal features that could be combined to produce lots of possibilities
- More of a recipe than an invention
- Core values
  - Simple wins
  - Reliable through replication
  - Must be inherently fast
  - Distribution of authority and control

Source: Nominum

Later Additions

- Dynamic Update
- DNSSEC
- TSIG

- Many false starts

Source: Nominum

Important other issues

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- DNS -> DN$
  - Marketing
  - Trademarks
  - ICANN
  - Etc
- Simple numbers
  - e.g. DoDNS
    - Root does 1 query/sec
    - Good queries take 100 msec

Source: Nominum

What would Buffett Say

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- “You can get in way more trouble with a good idea than a bad idea”
  - Ben Graham
- …because you forget that the good idea has limits
  - Warren Buffett
- “Life is like a snowball. The important thing is finding really wet snow and a really long hill.”
  - Warren Buffett

Source: Nominum

Scalability & Extensibility

Source: Nominum

Scalability

- Should MTU be in bits or time?
- For example:
  - 1990 ATM cell @ OC-3 = ~350 ns
  - 2008 Ether @ 10G = ~150 ns

- DNSSEC fundamentals suffering from inability to carry large signatures easily
- DNS-only expansion isn’t the answer
- TCP isn’t the answer

Source: Nominum

It’s the API, stupid

- Ethernet API has survived:
  - Change from passive multidrop to point to point
  - Copper to wireless to optical
  - Frame and address idea survived

- DNS API
  - RRs OK for a decade
  - Needs update now
    - Based on simple concepts
      - Set theory
      - hierarchy
    - Self defining new types

Source: Nominum

Standardizing can be tough

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- The affair “_”
  - ISC outlaws the “_”
  - Microsoft makes it required

- The IETF
  - “Don’t overload the DNS”
  - We’ll tell you what you can use in your DNS
  - Can’t be used for data needing security, except that it is.

Source: Nominum

Lessons

- We need a new, larger, datagram.
- We should rethink the conceptual model and clean it up, and extend it, in the process. Define the API.
- We don’t expect the file system to approve content; we shouldn’t do so in the DNS either.

Source: Nominum

Security

Source: Nominum

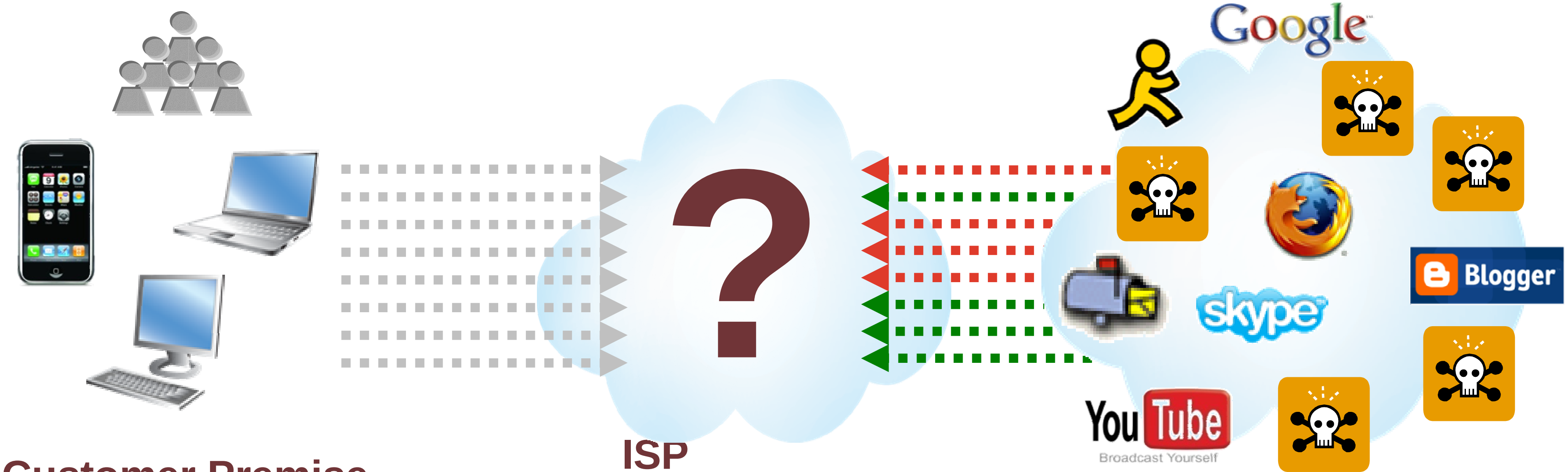
Today’s Discussion

- The DNS is exposed
- Subscribers are under attack
- The “Gap” between future technologies and today
- The Trusted Internet Experience –
  The TRUE Architecture

Source: Nominum

Rapidly Growing Problem

How to determine the difference between safe and harmful requests in real time?



Customer Premise

ISP
Broadband
Network

Internet
150 *million* malicious hosts
and growing…

How Can the Service Provider Help?

Source: Nominum

DNS History (past and future)

- 1983 DNS starts
  - » Intentional omissions include security, dynamic update, etc, etc
- 1986 DNS liftoff
- 1989 Cache Poisoning observed
  - » “Don’t cache data just because somebody sends it to you”
- 1989-2008 Various cache poisoning attacks
  - » Multiplexing technology adapted for security
  - » Other defenses deployed
- 1993 DNSSEC starts
- ~2000 Search makes “the missing directory” irrelevant
- 2008 Kaminsky fast poisoning attack

…

- 201X Majority of DNS secured with digital signatures

Source: Nominum

Statistical Attacks

Password

- Type login command
- Guess password
- Repeat till success

- Odds/guess:
  - Using “a-z, A-Z, 0-9” ~6 bits/character
  - 2 chars 1 in 3,884
  - 3 chars 1 in 238,328
  - 4 chars 1 in 14,776,336

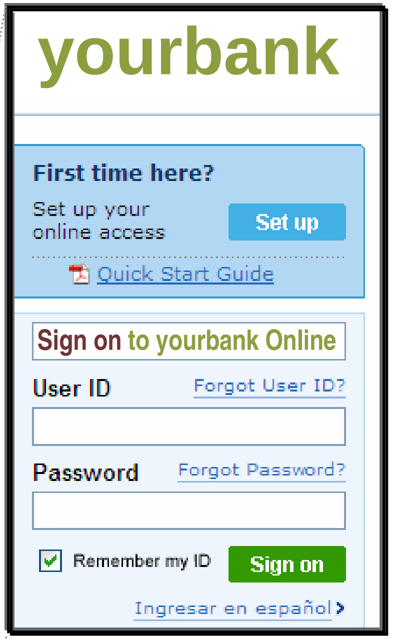
Kaminsky

- Send query so server listening for answer
- Send guesses while target DNS waits for real answer
- Repeat till success

- Odds/guess
  - 16 bit ID, 1 in 65536

Source: Nominum

How do Computers Navigate the Network?



yourbank

First time here?

Set up your online access

Set up

Quick Start Guide

Sign on to yourbank Online

User ID Forgot User ID?

Password Forgot Password?

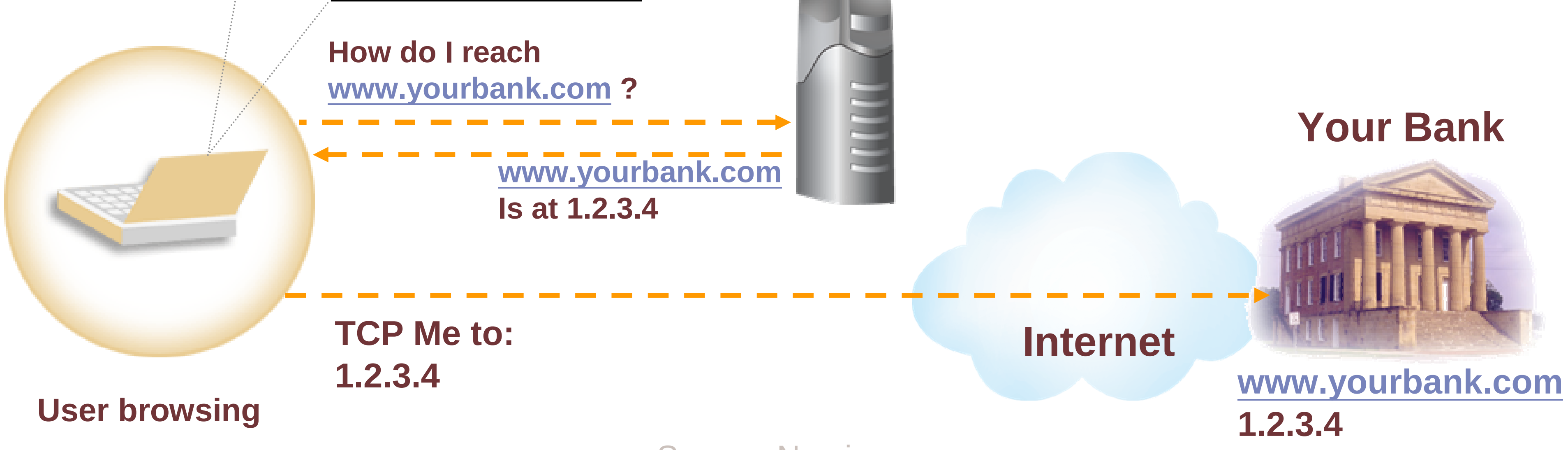
☑ Remember my ID

Sign on

Ingresar en español ›

To get to www.yourbank.com, the computer asks its local name server for directions.
For a company, it's the company's DNS server.
For a broadband user, it's the ISP's.

ISP or
Enterprise
Caching
DNS



How do I reach www.yourbank.com ?

www.yourbank.com
Is at 1.2.3.4

TCP Me to:
1.2.3.4

User browsing

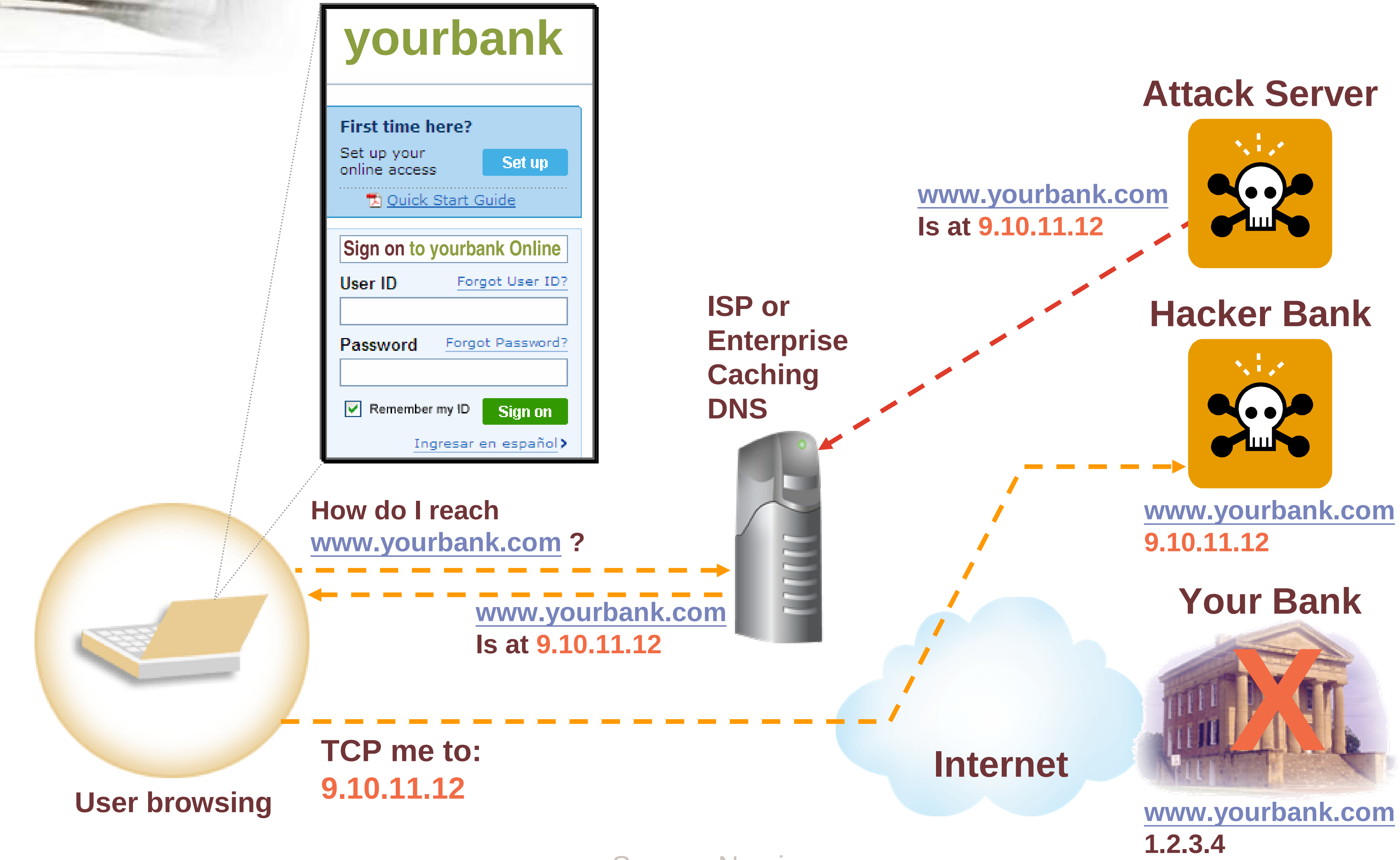
Internet

Your Bank

www.yourbank.com
1.2.3.4

Source: Nominum

Cache Poisoning Attack



yourbank

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Set up

Quick Start Guide

Sign on to yourbank Online

User ID

Forgot User ID?

Password

Forgot Password?

☑ Remember my ID

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Ingresar en español ›

Attack Server

www.yourbank.com
Is at 9.10.11.12

ISP or
Enterprise
Caching
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Hacker Bank

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9.10.11.12

How do I reach
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Internet

User browsing

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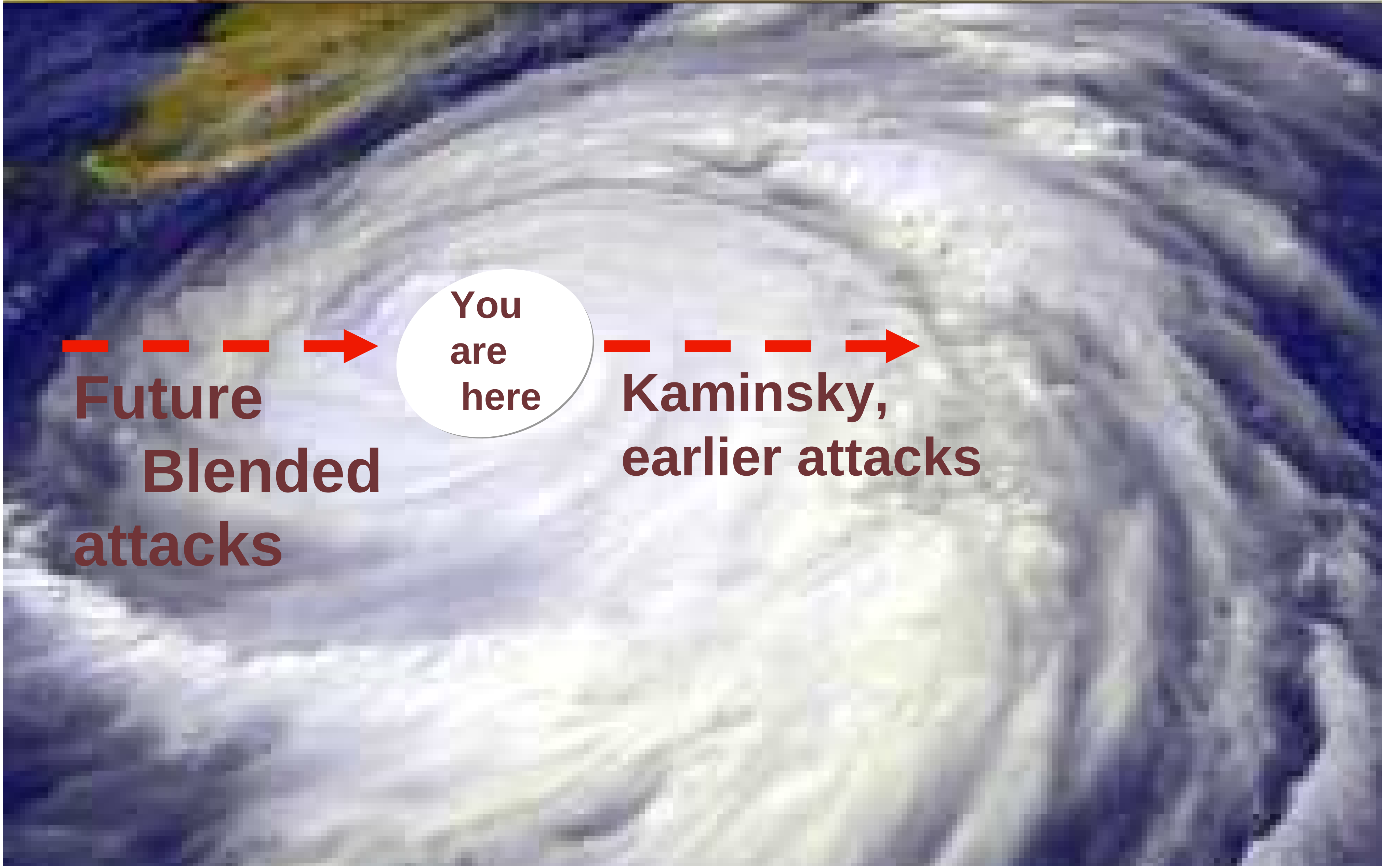
Source: Nominum

The Eye of the Hurricane



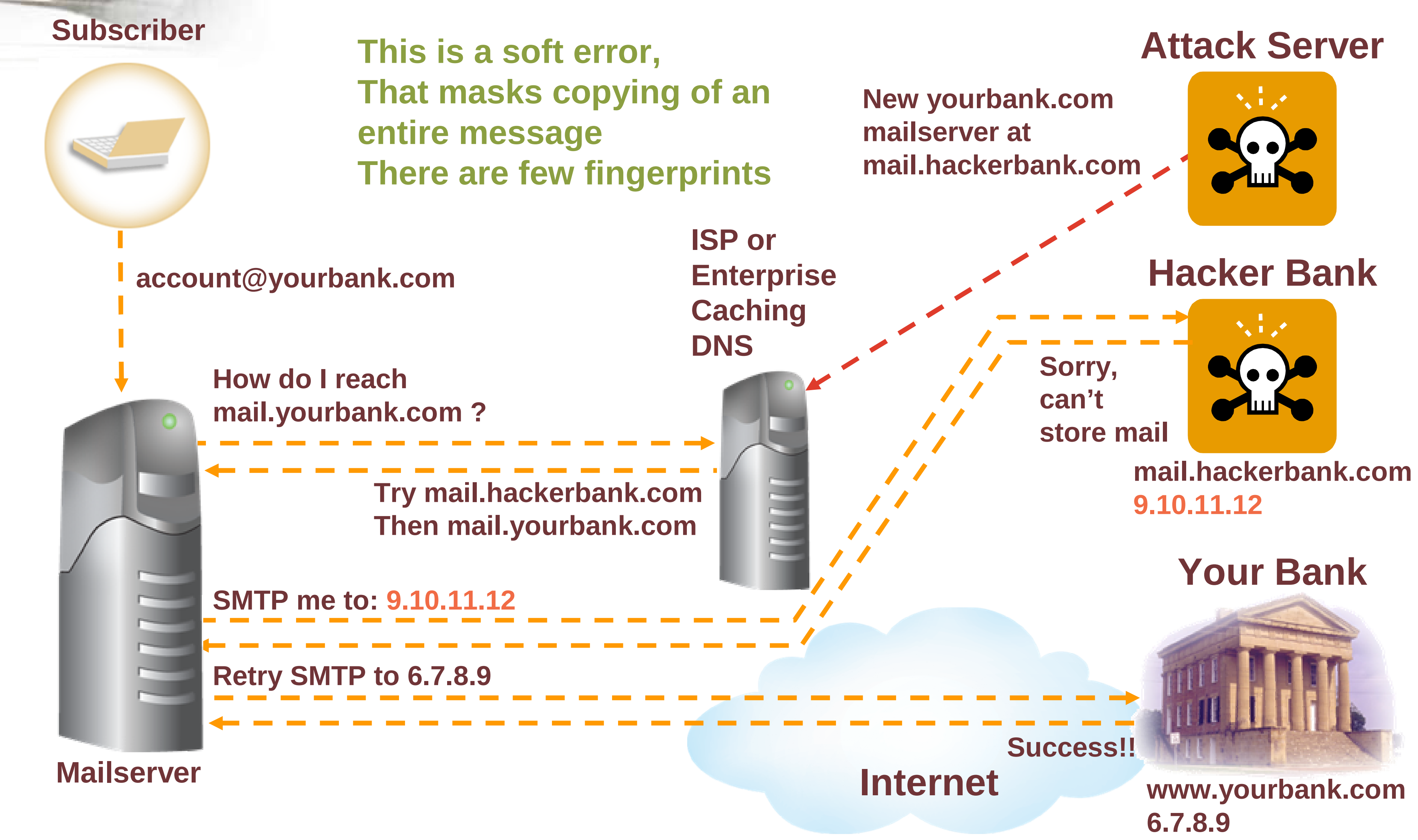
Future Blended attacks

You are here

Kaminsky, earlier attacks

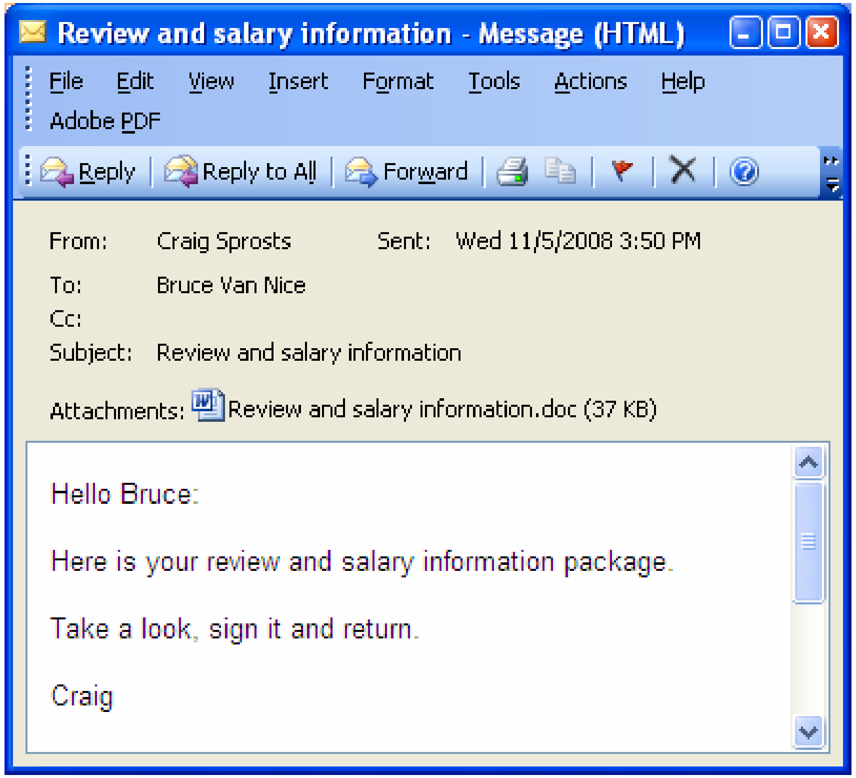
Mail Attack

This is a soft error,
That masks copying of an entire message
There are few fingerprints



Source: Nominum

Two Messages


Review and salary information - Message (HTML)
File Edit View Insert Format Tools Actions Help
Adobe PDF
Reply
Reply to All
Forward

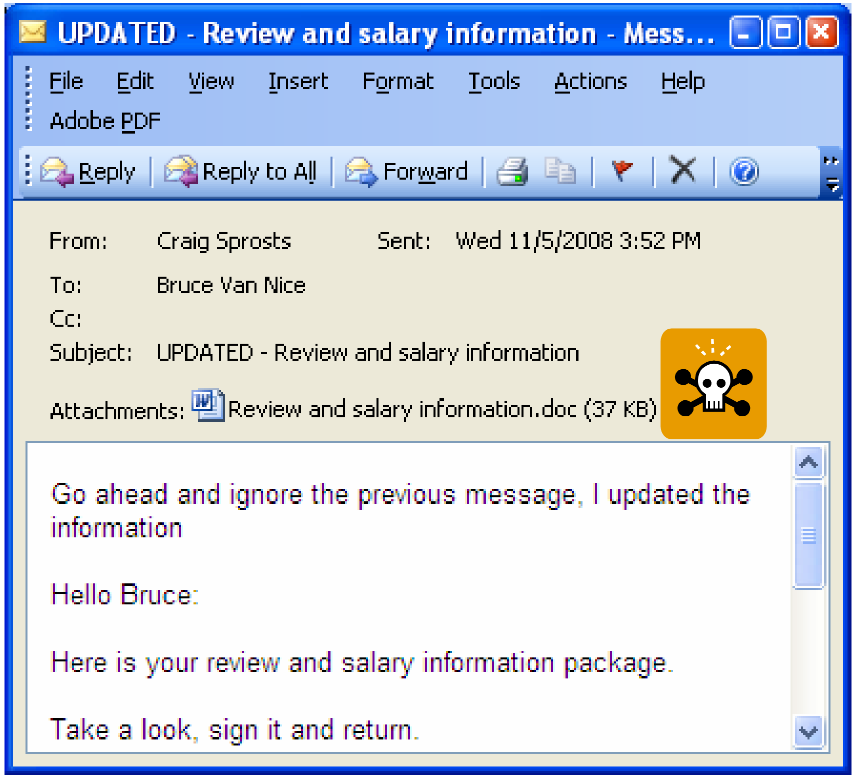
From: Craig Sprosts Sent: Wed 11/5/2008 3:50 PM
To: Bruce Van Nice
Cc:
Subject: Review and salary information
Attachments: Review and salary information.doc (37 KB)

Hello Bruce:

Here is your review and salary information package.

Take a look, sign it and return.

Craig


UPDATED - Review and salary information - Mess...
File Edit View Insert Format Tools Actions Help
Adobe PDF
Reply
Reply to All
Forward

From: Craig Sprosts Sent: Wed 11/5/2008 3:52 PM
To: Bruce Van Nice
Cc:
Subject: UPDATED - Review and salary information
Attachments: Review and salary information.doc (37 KB)

Go ahead and ignore the previous message, I updated the information

Hello Bruce:

Here is your review and salary information package.

Take a look, sign it and return.

Source: Nominum

IETF USPR response: Augment IDs with ports

- Old ID-only: 1 chance in 65,536
- ID + port: 1 chance in 4,294,967,296
- But
  - Doesn't work with load balancers
    - Back to 1 chance in 65,536
  - Slows servers

Source: Nominum

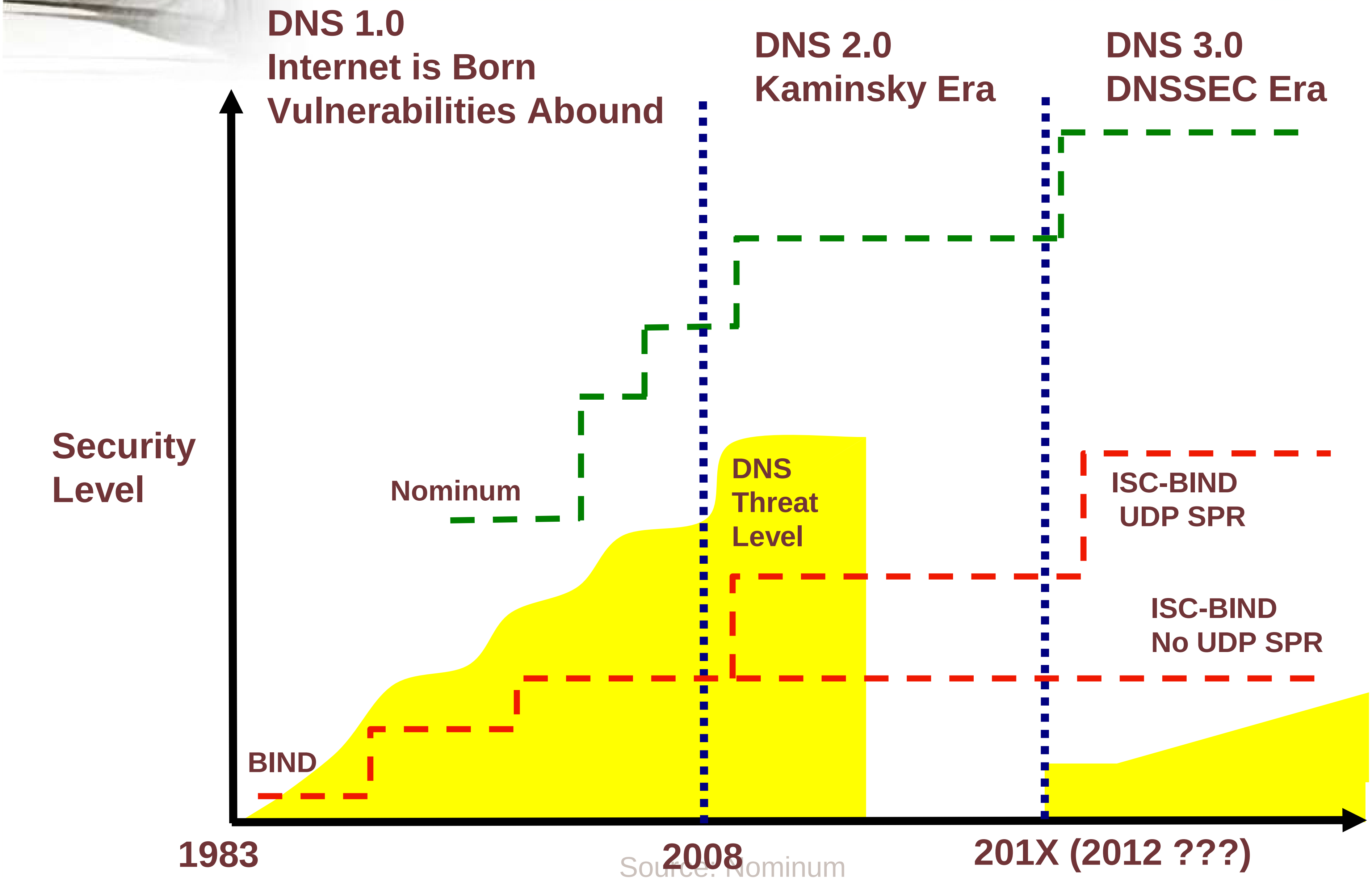
Hacker response to USPR: increase attack rate

- One experiment showed that an attack over a gigabit network defeated USPR in 10 hours using 2 machines.
- That attack was unlucky; attack works faster on average
- Coordinated attacks via botnets
- Attack .COM or .JP and own all names below

USPR isn’t enough.

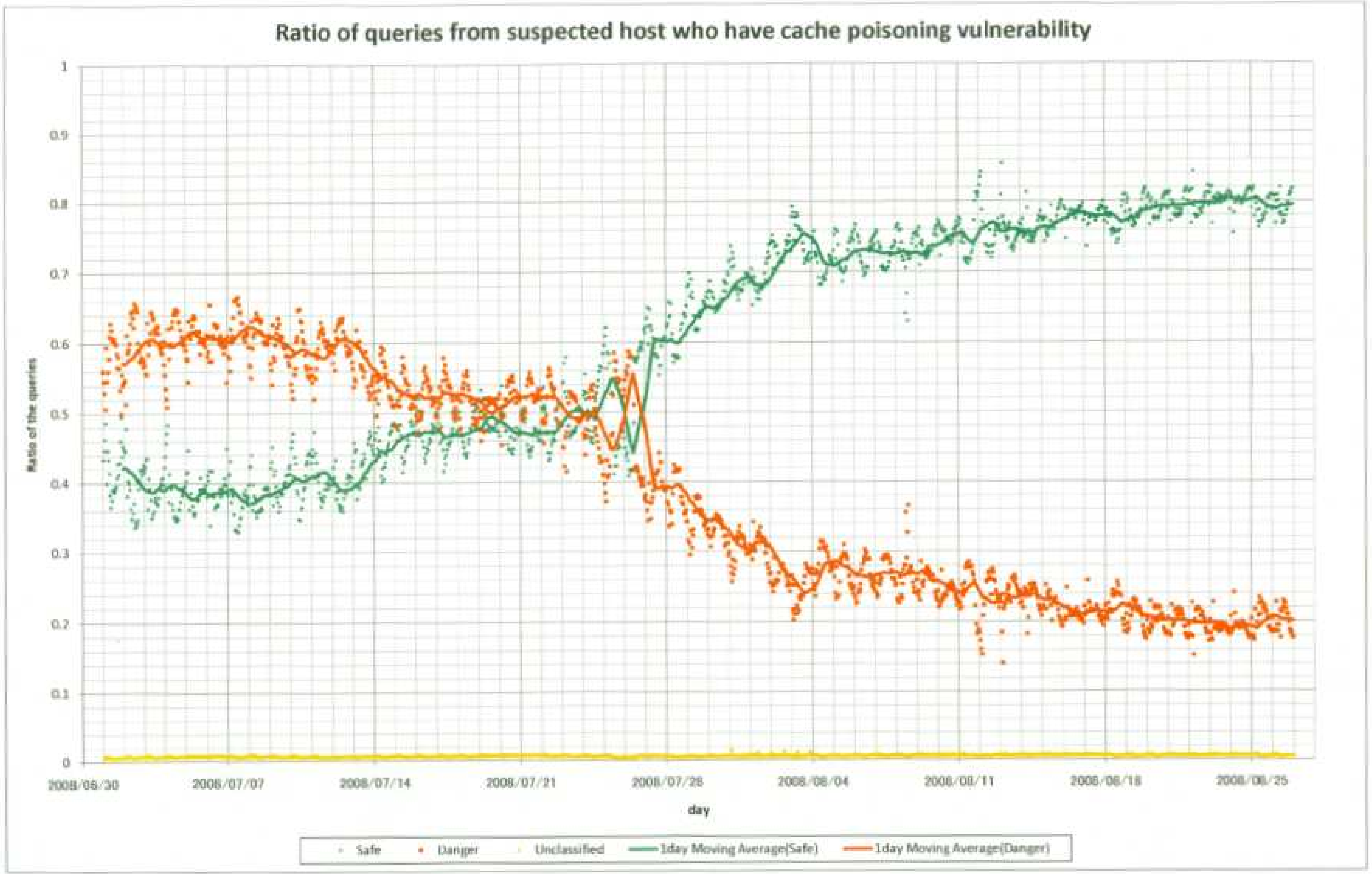
Source: Nominum

A Changing World



Source: Nominum

How safe is the Internet?



Source: Nominum

Lessons

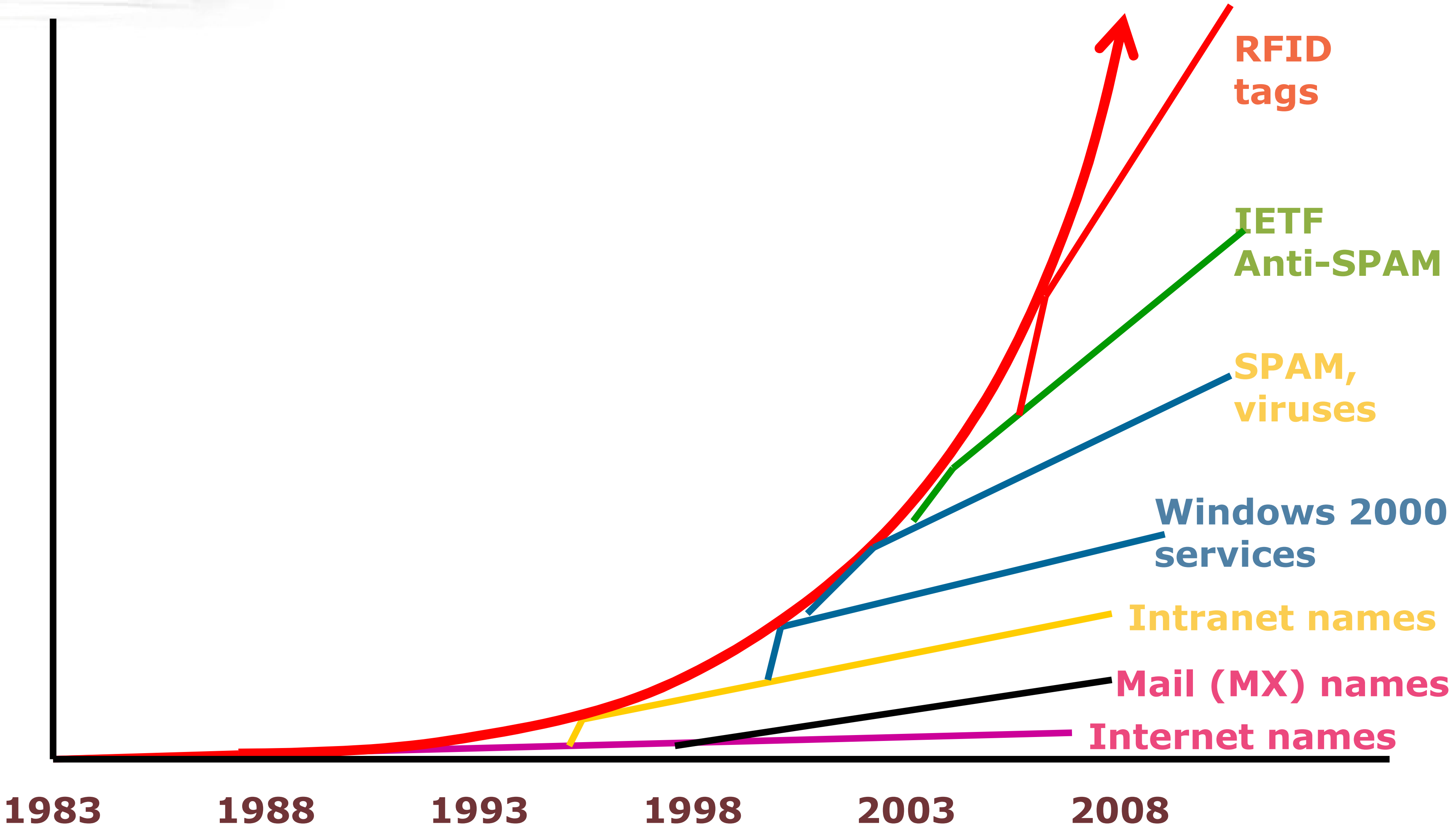
- We need strategies to improve DNS security
  - Near term which can be deployed now
  - Long term enhancements (DNSSEC?)
- Speed kills (faster nets are more vulnerable)
  - Enterprise at risk from infected machines
  - Secure your DNS with a 10Mbit connection?
- DNS servers embedded in appliances, etc may not be easily upgradable

Source: Nominum

New Applications

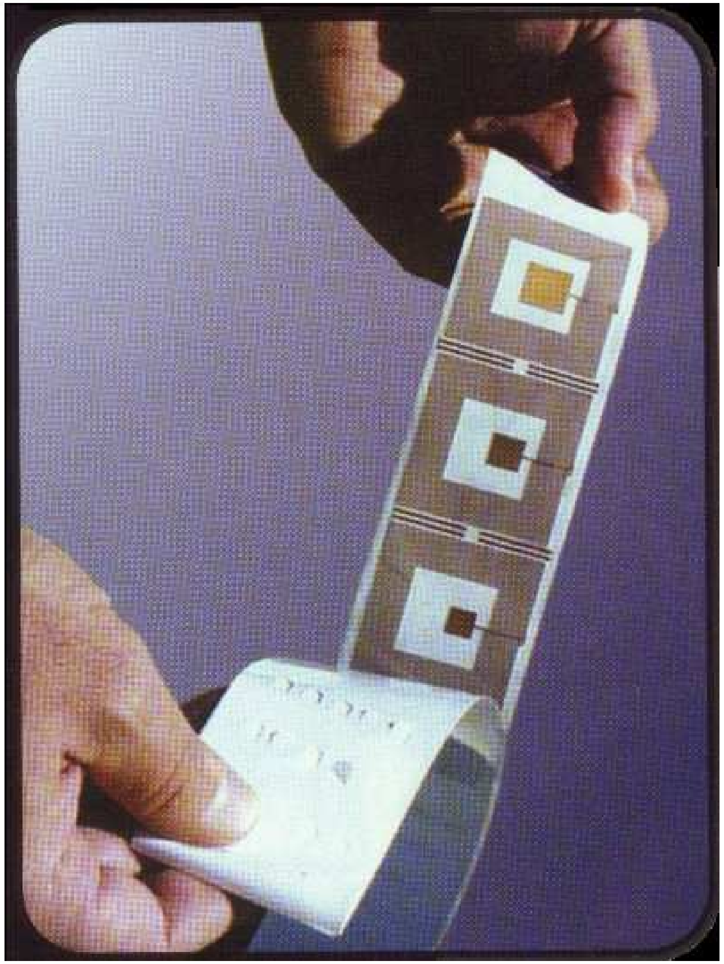
Source: Nominum

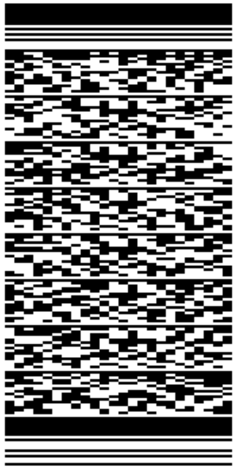
DNS use is growing exponentially

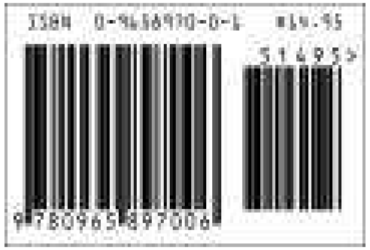


Source: Nominum

RFID’s Origins







Source: Nominum

Why RFID is hard

- Legacy
  - Multiple existing name spaces
  - Multiple objectives (e.g. pallets vs. razor blades)
  - Varying Tag intelligence
    - Active (powered)/passive
    - Internal smarts

- Future
  - Privacy concerns
  - Standards body structure
    - Hardware IPR vs. software IPR

Source: Nominum

History

- MIT AutoID Center, with industry, defines:
  - Set of physical tag standards
  - Format for the binary string tags return
- Results turned over to EPCGlobal, a standards organization, with bar code experience, et al.

Source: Nominum

The Curious Devolution of the ONS Standard

- MIT Auto-ID Center defines
  - 96 bits of data per RFID tag
  - Object Naming System (v 0.5)
    - Layer over DNS
    - Variable sequence of fields for encoding all 96 bits

- EPC Global “improves” to
  - 96 bits of data per RFID tag
  - Object Naming System (v 1.0)
    - Layer over DNS
    - Fixed 3 levels
      - Header (numbering scheme)
      - General Manager (subowner of name space, e.g. company)
      - Object Class (e.g. SKU)
    - Remaining bits up to other protocol

Source: Nominum

ENUM

- Idea: Let’s have a standard that uses the DNS to route phone calls (and other new media)
- Problem: ENUM uses only destination number to route, real world uses more fields than that.
- Problem: Equipment manufacturers want intelligence, i.e. value, in their product.
- Problem: Legacy data owners really don’t want to change ownership scheme.
- Problem: Security is used as issue.

Source: Nominum

Lessons

- Displacing a legacy model is more than technology
- Catalysts for new developments
  - Security
  - Self defining data types
- The next new applications
  - Threat feed and configuration data to all enforcement devices, e.g. firewalls, mail servers, …

Source: Nominum

Final Thoughts

Source: Nominum

Facts to face

- ICANN isn’t “too political”
  - ICANN *is* politics
  - Apply the usual political safeguards, checks, and balances
- We shouldn’t worry about overloading the DNS
  - We should worry about perfect standards that take decades
  - More evolution, less intelligent design
  - Even if extinction is the next step

Source: Nominum

The future

- Continuing struggle between two factors
  - “The Internet changes everything!”
  - “For every action, there is an equal and opposite reaction.”
- The real world pushes back, excesses provoke reform, …

Source: Nominum

Replacing/Extending DNS

- Process:
  - I. Assemble set of key problems
  - II. Generalize
  - III. Prune
  - IV. Postulate a solution
  - V. Test

Source: Nominum

Worthy Problems

- IPv4 address space exhaustion and LISP
  - Layer of indirection for IPv4 addresses
  - Double size of tracked address space
  - Merge route flap and quasi-static multi-homed assignmants
- AS numbers going to 4 bytes
  - Hard to type
  - Can we distribute mnemonics

Source: Nominum

Q & A