Scaling the Root

A study of the impact on the DNS root system
of increasing the size and volatility of the root zone

Jaap Akkerhuis   Lyman Chapin
Patrik Fältström   Glenn Kowack
Lars-Johan Liman   Bill Manning

Summary of Findings

IEPG meeting
IETF 76, Hiroshima, Japan, 8 November 2009

1

Root Scaling Study

- Requested by ICANN Board
- Steering group formed early 2009
  - representatives from SSAC, RSSAC, Staff
- Study team commissioned May 2009
  - Lyman Chapin (lead)
  - Jaap Akkerhuis, Glenn Kowack, Patrik Fältström, Lars-Johan Liman, Bill Manning
- TNO root scaling model
  - Developed by TNO under direction of and input from the Root Scaling Study Team

2

Root Zone Expansion

- New resource records for DNSSEC

- Internationalized top-level domain names

- New address records and glue for IPv6

- New gTLDs

  → Root zone becomes larger (size)

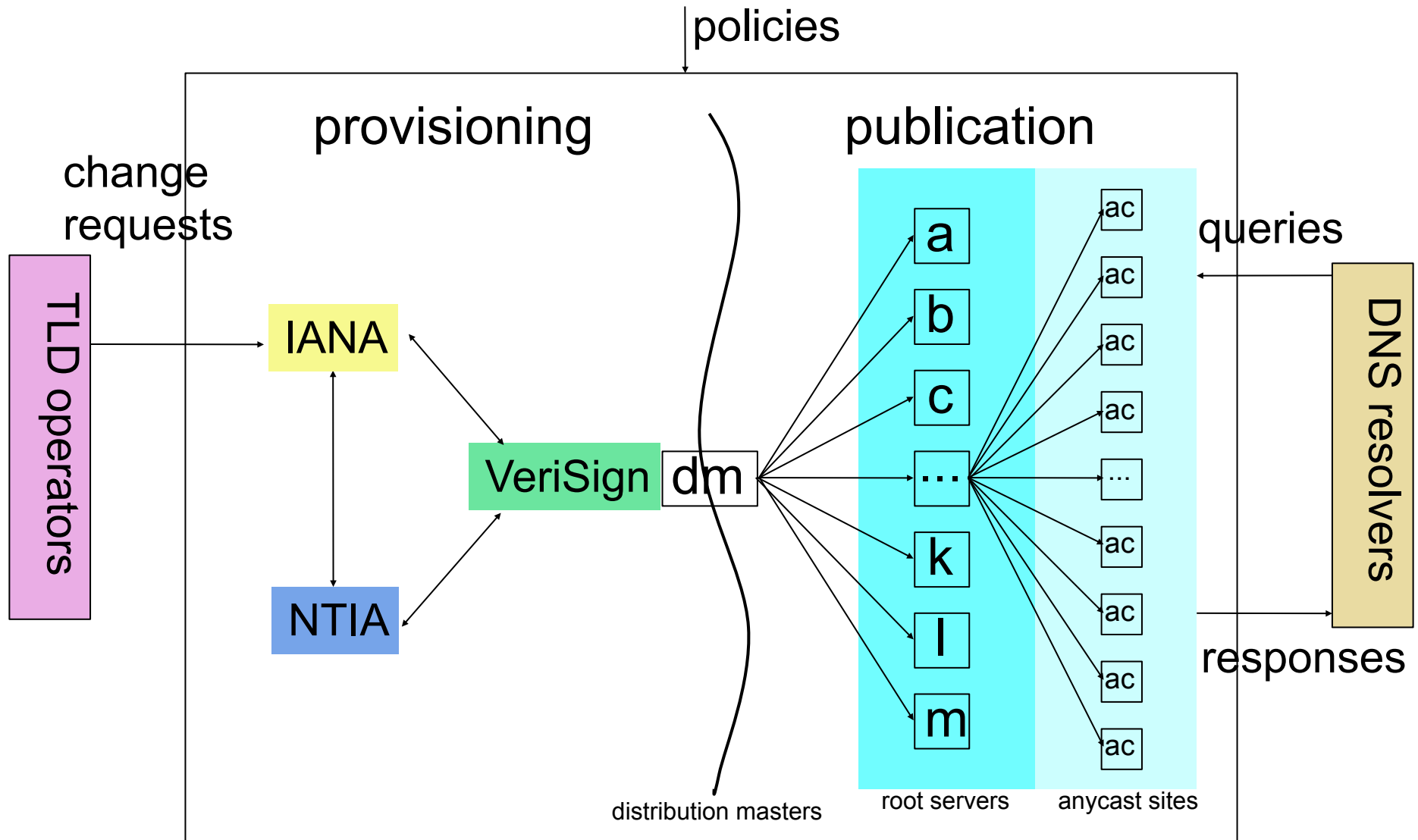 → Change rate increases (volatility)

Information Gathering

- Interviewed all 12 root server operators
  - 2–4 hour telephone interviews
  - System designs
  - Management structures
- US Dept. of Commerce
- IANA function (ICANN)
- Root zone editor (Verisign)

4

Information Gathering

- Outreach to big DNS user organizations
  - Large corporations
  - Internet Service Providers
  - TLD operators – registries
  - TLD name server operators

- Presence at conferences
  - Announcements
  - Solicitated input

Root System Model

policies

provisioning   publication

change requests

queries

TLD operators

IANA

VeriSign | dm

NTIA

a
b
c
...
k
l
m

ac
ac
ac
ac
ac
...
ac
ac
ac
ac

DNS resolvers

responses

distribution masters   root servers   anycast sites
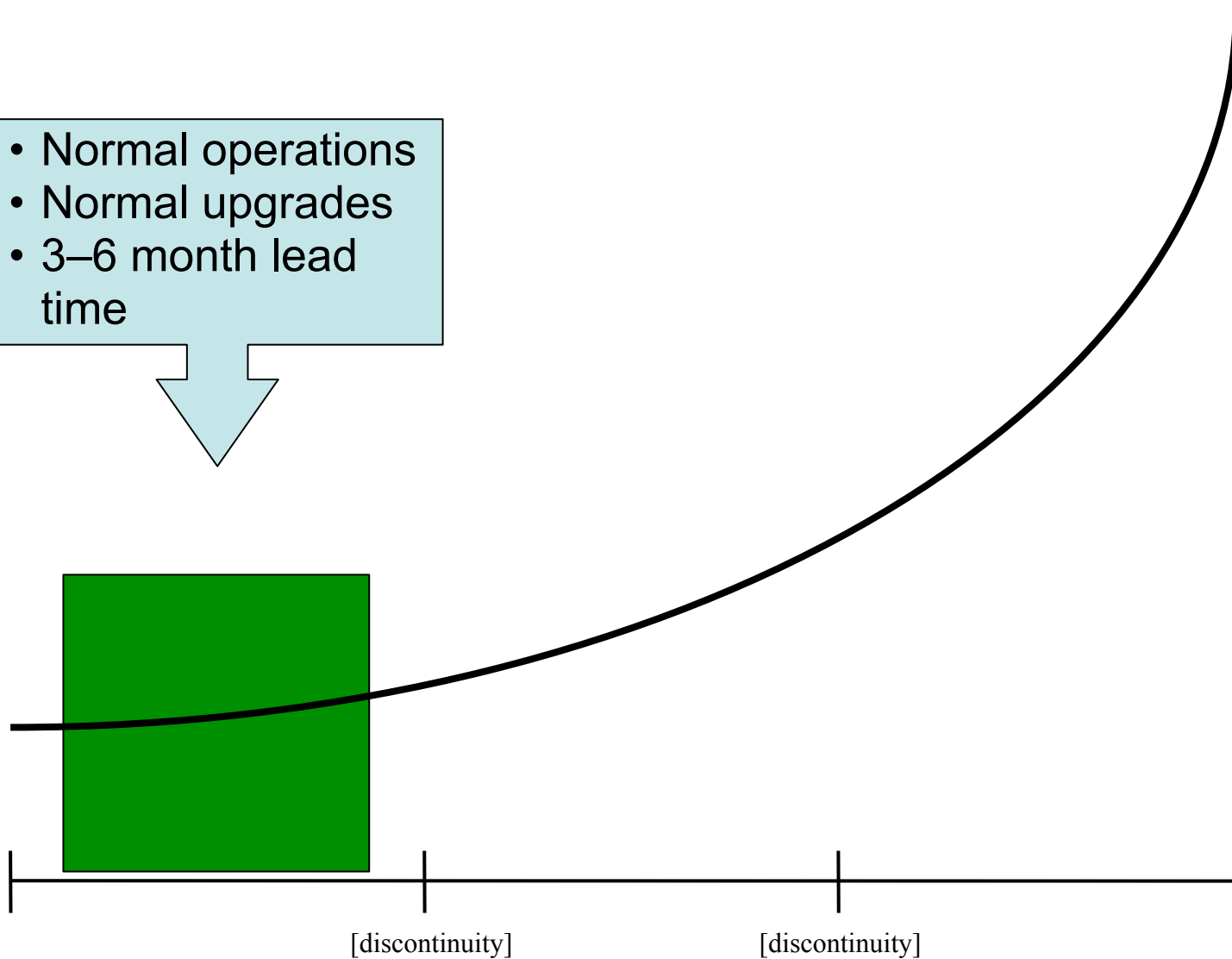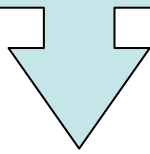
The Root Server System

- The root is a highly decentralized and dynamic system
  - Many small moving parts, with engineers greasing cogwheels, replacing parts, rebuilding, and improving the system all the time.
  - The operators will ensure that the system adapts as the requirements on the systems evolve
- There is no known sharp limit beyond which the system will suddenly "explode"
- There is some instrumentation in parts of the system that will display warning signs when those parts are under stress
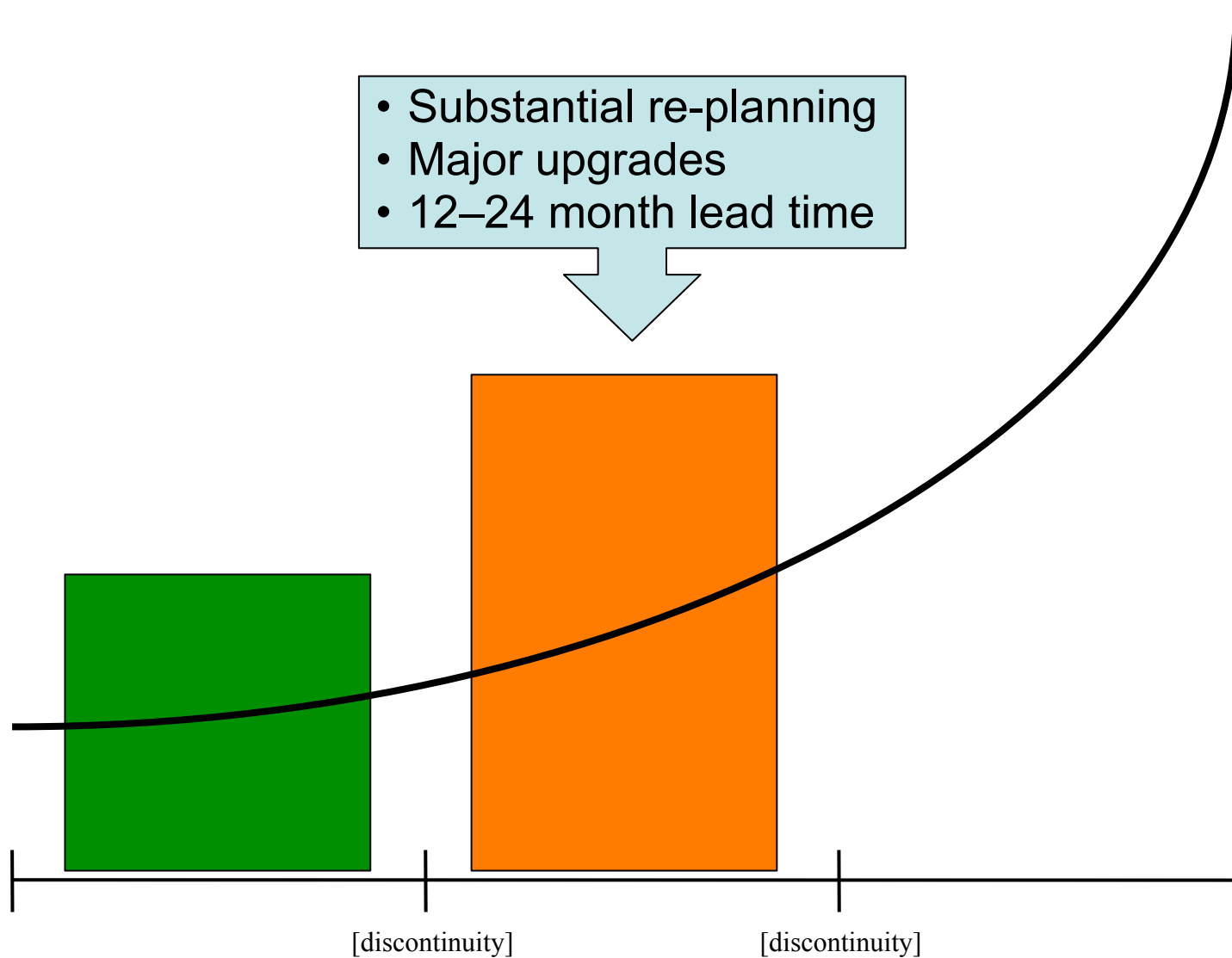
7

Introducing Changes

- The root system is flexible and adaptable!
  - But not instantaneously
  - System is build for resilience, not for growth
  - If the operational requirements change at a controlled pace, the system can adapt and maintain operational headroom
- Any increase in the size or volatility of the root zone involves risk.
  - It's all about managing the risks.

8

Dynamic Operating Regions

- Normal operations
- Normal upgrades
- 3–6 month lead time

[discontinuity]   [discontinuity]

Dynamic Operating Regions

- Substantial re-planning
- Major upgrades
- 12–24 month lead time

[discontinuity]   [discontinuity]

Dynamic Operating Regions

- Major redesign of entire root data distribution model, (administrative, technical and financial)
- Massive upgrades
- Several years lead time

[discontinuity]   [discontinuity]
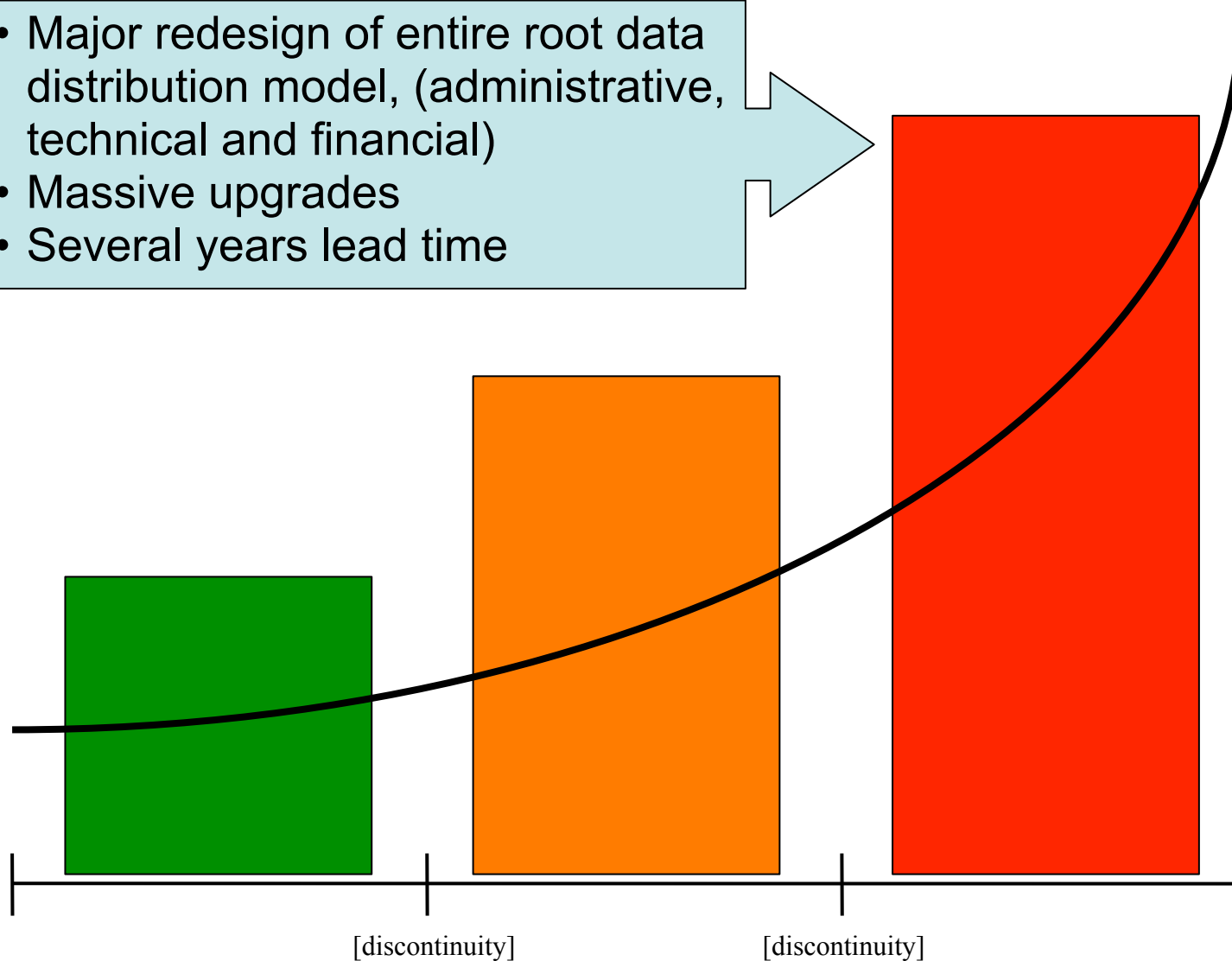
Types of Stress

- ## Zone size
  - – In itself not much of a problem ...
  - – ... but a bigger zone leads to ...

- ## Zone volatility
  - – Affects the volume of data per unit of time that needs to be transferred from the distribution masters to the individual root servers.

Sudden Step Changes

- Change the behaviour of the servers
  - *Introducing* AAAA (IPv6) records
  - *Introducing* DNAME records
  - *Introducing* DNSSEC
    - Handle DNSSEC record types
    - Significant increase in zone size and volatility
    - Amplification factor for other changes

Gradual Changes

- Adding more TLDs
  - More of "the same"
  - Adding IDN names
  - To the system, all TLDs are equal
    gTLD = ccTLD = IDN TLD
    - "Variants" management
      - Using NS records = more of "the same"
      - Using DNAME records = transient!

- Adding more AAAA (IPv6) records
  - More of what we already have

14

Other Issues?

- Increased response size
  - Will generate additional traffic.
- Query rate?
  - Well met by current amount of hardware.
- Malformed queries?
  - Yeah, there are plenty of those ...
  - Handled by software, and close cooperation with software vendors.

Neither of these pertain to the content of the database (the root zone).
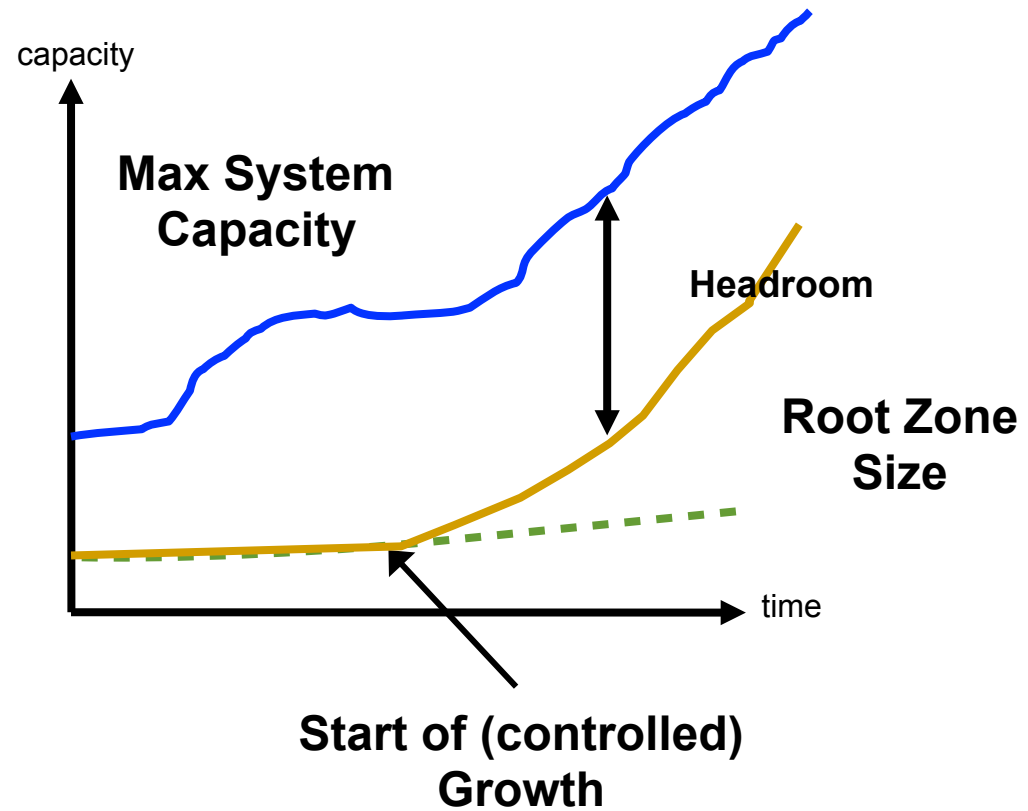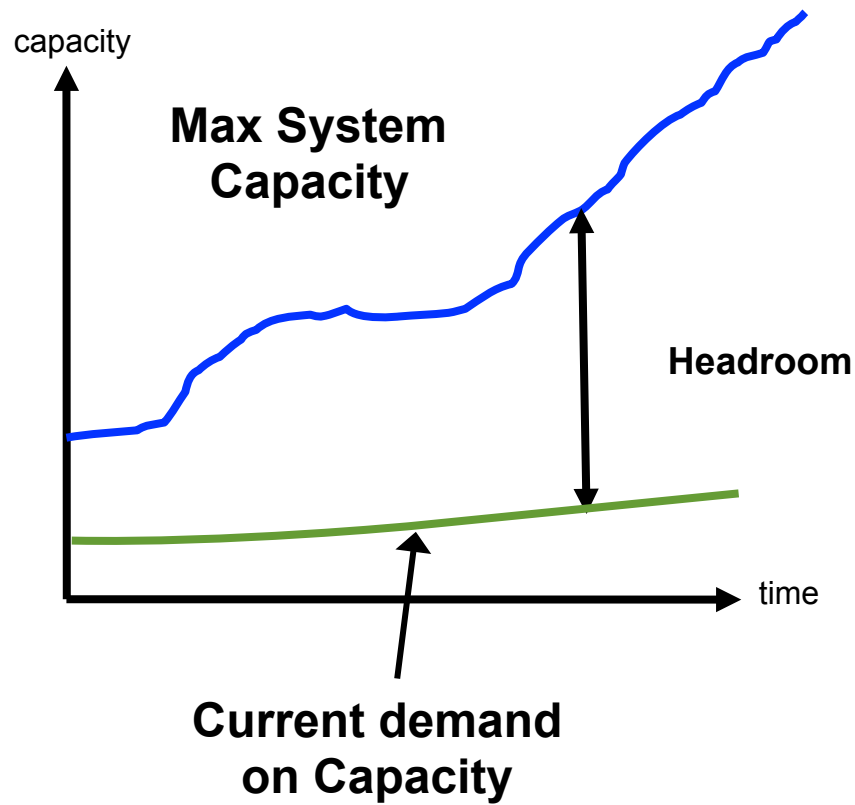
15

Findings

- The following findings should be read in the context that coordination needs to happen between all the involved parties – on both the provisioning side, and on the publication side.

- It's crucial to coordinate, plan, and watch all parts of the systems carefully.

Findings

- On the provisioning side, the ability to scale the root is completely dominated by the steps that involve human intervention

- On the publication side, scaling the root primarily affects poorly-connected Internet locations.

- The risks associated addition of a few hundred TLDs can be managed without changing any actor's current arrangement

- The risks associated with an annual increase in the size of the root zone on the order of thousands of new entries can be managed only with changes to the current arrangements of one or more actors
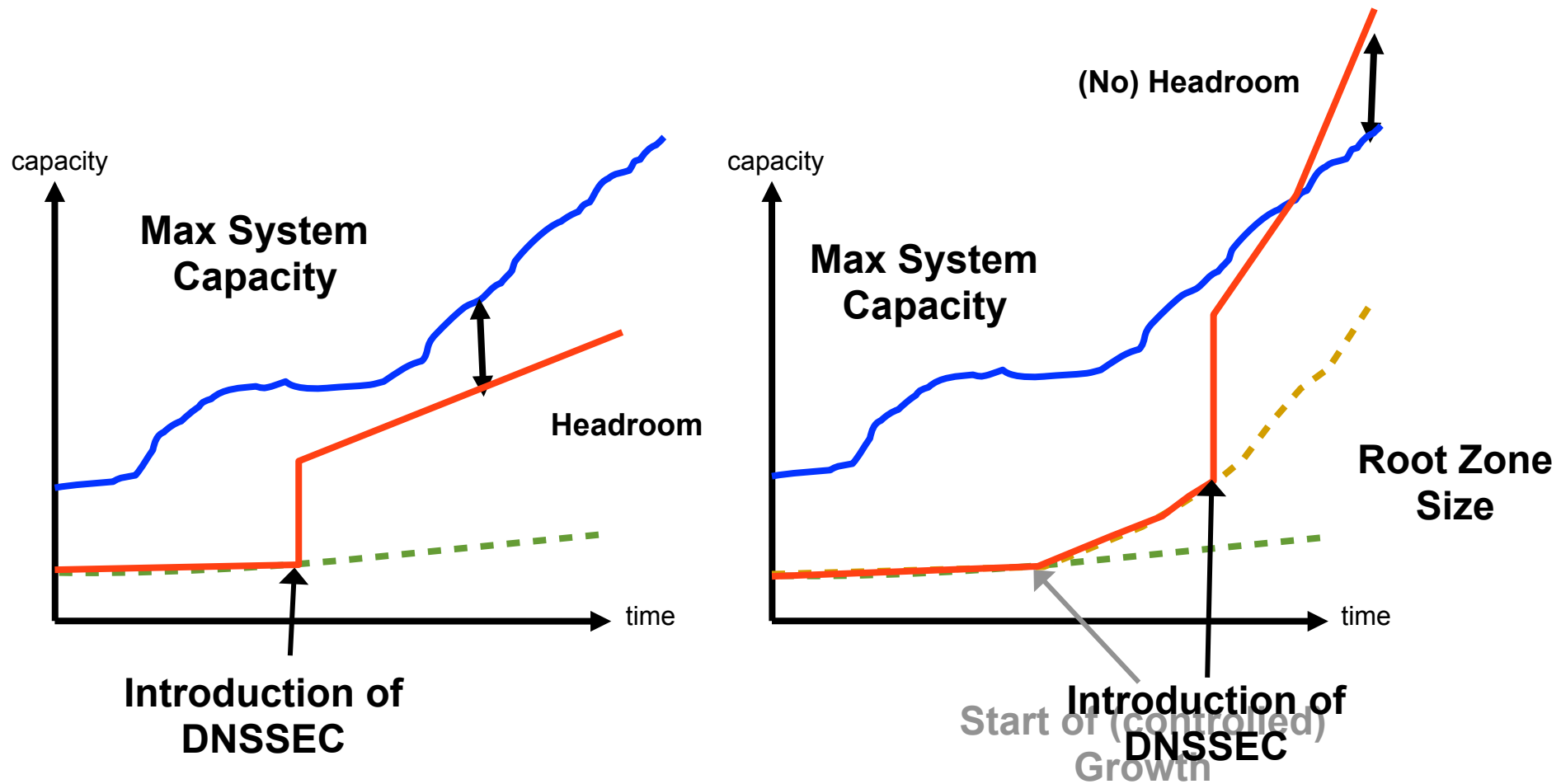
17

Root Server System Headroom

Impact of added records

capacity

Max System Capacity

Headroom

time

Current demand on Capacity

capacity

Max System Capacity

Headroom

Root Zone Size

time

Start of (controlled) Growth

18

Root Server System Headroom

Impact of introduction of DNSSEC

"Early Warning Systems"

- Root system oversight should focus on "early warning" rather than threshold prediction.

- In order for "early warning" to be effective, changes to the root must be at a controlled pace.

- Additional instrumentation is needed to provide better early warning.

- Beware of "critical sections"!

  – Additions to the root that, once started, cannot be stopped (e.g. famous trademarks).

20

Effects of Root Zone Changes

	New TLDs	DNSSEC	IDNs	IPv6 addresses
Increases number of TLD entries in the root zone	X		X	
Increases size of the root zone file	X	X	X	X
Increases amount of data per TLD		X	X	X
Increases number of variables per TLD		X		X
Increases number of changes per TLD per year		X		X

21

Questions?

Questions?

Dedication

The root scaling study is dedicated to a root of impressive scale, the Mangelwurzel, which enjoys the dubious distinction of having suffered greater abuse and indignity than the root of the DNS.

A mangelwurzel hurling championship was revived in the north Wiltshire village of Sherston on October 7, 2006. Teams of three hurled mangelwurzels in turn, aiming to be the closest to a large leafless mangelwurzel known as "the Norman."

Contemporary accounts of this event do not record whether or not the villagers conducted a thorough study of the security and stability of "the Norman" before beginning their assault.