End of the Internet Predicted!

Torrent at 11

The Oracle Bones of IPv4

Some personal divination by
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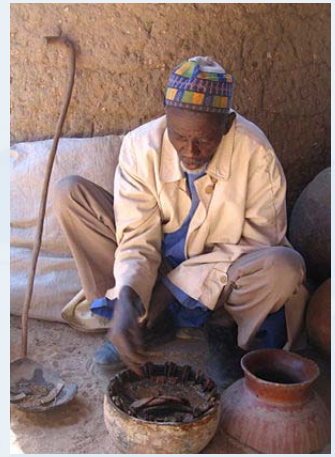
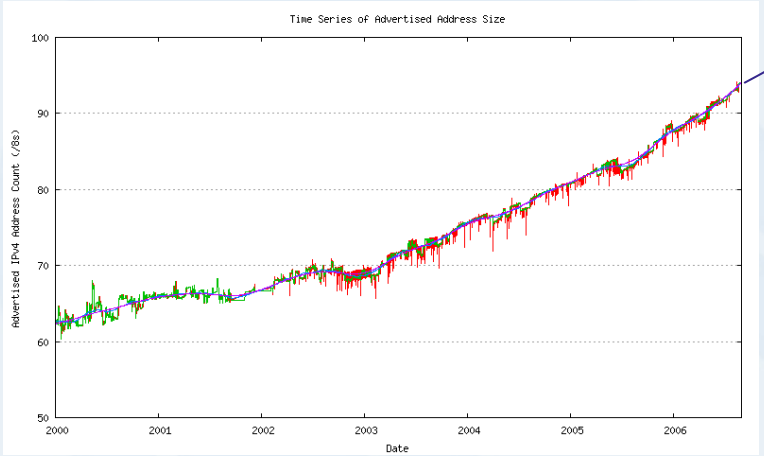
The Art of Divination





The Oracle Bone Questions:

1. When will we ‘exhaust’ IPv4?

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- You need to define ‘exhaustion’
  - There are folk still coding in Fortran out there – somewhere!
- Is “exhaustion”:
  - Turning off the last IPv4 protocol stack?
  - IPv4 ceasing to be commercially viable as a service platform?
  - No more IPv4 addresses?
  - IPv4 becoming overwhelmed by NATs?

IPv4 Address Exhaustion?

A. When will we stop routing IPv4 in our networks?
  – We will probably still route IPv4 for some decades to come

B. When will the RIRs have no more IPv4 addresses to distribute?
  – Sometime between 2009 and 2012

C. When will IANA have no more IPv4 addresses to pass to the RIRs?
  – Sometime between 2009 and 2012

The Oracle Bone Questions:

1. When will we ‘exhaust’ IPv4?

2. Why is this a problem?

2. Why is this a problem?

- Today, the unallocated pool meets growth demand for IPv4-based Internet service deployment
- In the absence of an unallocated address pool to satisfy growth demands:
  - Un-met address demand will increase
  - Placing an escalating global scarcity premium on IPv4 addresses

2. Why is this a problem?

- This scarcity may create pricing pressure on IPv4 addresses
  - Where demand exceeds supply then price escalation is a common outcome in classic markets
- This imposes additional costs on industry players
  - These costs may place IPv4 addresses out of reach of some players
- Which, in turn, may cause additional costs for end consumers of Internet services
- These are probably undesirable outcomes that may not be equitable, efficient or effective

The Oracle Bone Questions:

1. When will we ‘exhaust’ IPv4?
2. Why is this a problem?
3. What will happen at the ‘exhaustion’ point?

3. At the IPv4 Exhaustion Point …

What are our choices?

Our current options are one, or more, of:

⇒ **IPv4 + NATs**

⇒ **IPv4 trading markets**

⇒ **IPv6 deployment**

NAT-PT + IPv4?

- Deploy more NAT-PT units within the network
  - How much will it cost? Can the cost be externalized?
  - What services can / cannot be offered? Can these services adapt to NATs?
  - How long / how large can such a NAT strategy last?
  - Will it scale?

Are NATs viable in the short term?

Yes

- Deployment costs are externalized away from network operators
- They support a viable subset of Internet services
- They are already extensively deployed
- They have already influenced application architectures

Are NATs viable in the long term?

Probably not, in the very long term

The major problem with NATs from an application implementation perspective is the non-uniformity of NAT behaviour

– this could be fixed

The major problem with NATs from an application architecture perspective is complexity bloat:

- application-specific identification domains,
- NAT-mediated application-specific rendezvous functions,
- multi-party distributed state application behaviours
- multi-ganged NAT behaviours
- Compromised end-to-end communications security properties

– there is no easy fix for this

3. At the IPv4 Exhaustion Point …

What are our choices?

One or more of:

⇒ **IPv4 + NATs**

⇒ **IPv4 trading markets**

⇒ **IPv6 deployment**

IPv4 Trading?

- Redistribution of IPv4 address blocks through the operation of trading markets?
  - How can such markets operate?
  - How much will IPv4 addresses cost now?
  - How much will IPv4 addresses cost later?
  - Can the outcomes continue to be routed?

IPv4 Trading?

- Balancing supply and demand through an open market with price signals
  - For a seller – the ability to capitalize the value of under-used resources
  - For a buyer – place a utility efficiency value on access to the resource
- Risks:
  - Market distortions
  - Price uncertainty
  - Captive buyers
  - Speculative market players
  - Regulatory intervention
  - Routing load through address block fragmentation

Is an IPv4 trading market viable for the short term?

- Probably yes
  - This is a conventional distribution function which could be undertaken through interactions between address sellers and buyers
  - Price signals could provide motivation for greater levels of efficiency of address deployment in IPv4 deployments
  - Within such a framework there are potential implications for the viability of the routing system which are not well understood

Is an IPv4 trading market viable for the long term?

Unlikely, but hard to tell

An IPv4 address trading market can provide a short term incentive to expose unused addresses for reuse, and can provide incentives for high address utilization efficiencies

An IPv4 market exposes additional risk factors in variability of supply availability and pricing that are expressed as cost elements to the service provider

An IPv4 market does not create new IPv4 addresses. An address trading market cannot fuel network growth indefinitely.

Markets cannot make the finite infinite.

3. At the IPv4 Exhaustion Point …

What are our choices?

One or more of:

⇒ **IPv4 + NATs**

⇒ **IPv4 trading markets**

⇒ **IPv6 deployment**

IPv6 Deployment?

- Deploy IPv6
  - How much will it cost?
  - How long will it take?
  - When will customers and services transition?
  - When can we stop also supporting IPv4?

IPv6 short term viability?

- Still uncertain
  - Few immediate commercial incentives to drive ISP deployment
  - No evident ability to externalize deployment costs – NATs look more “attractive” for deployments in the short term
  - No dense service base and few compelling services to drive consumer-level demands

IPv6 – long term viable?

Given the state of the current alternatives - it had better be!

It offers leverage into larger networks with stronger characteristics of utility service models. It has the potential to reduce some of the complexities of network service architectures.

But the gains here are long term outcomes, while the transition costs are short term hits

The Oracle Bone Questions:

1. When will we ‘exhaust’ IPv4?
2. Why is this a problem?
3. What will happen at the ‘exhaustion’ point?
4. What are the implications for industry players?

4. Implications

- there is no “flag day” for transition
- IPv4 addresses will continue to be in demand beyond the date of exhaustion of the unallocated pool
  - But the mechanisms of management of the address distribution function, and the price, will change
- coexistence of multiple service models is expensive

  IPv4 markets + IPv4 / NATs + IPv6 = $$$

4. Implications

For network managers:

- Understanding growth requirements and matching this to address accessibility
- Forward planning to minimize disruption risk

For product and service vendors:

- Planning ahead of demand rather than lagging
- Surprises in any massive industry are unpleasant and messy – you need to think beyond the current technology platform

For regulators and policy makers:

- Phrasing clear and achievable objectives with unambiguous regulatory signals to industry players

4. Implications

It is likely that there will be some disruptive aspects during this exhaustion condition

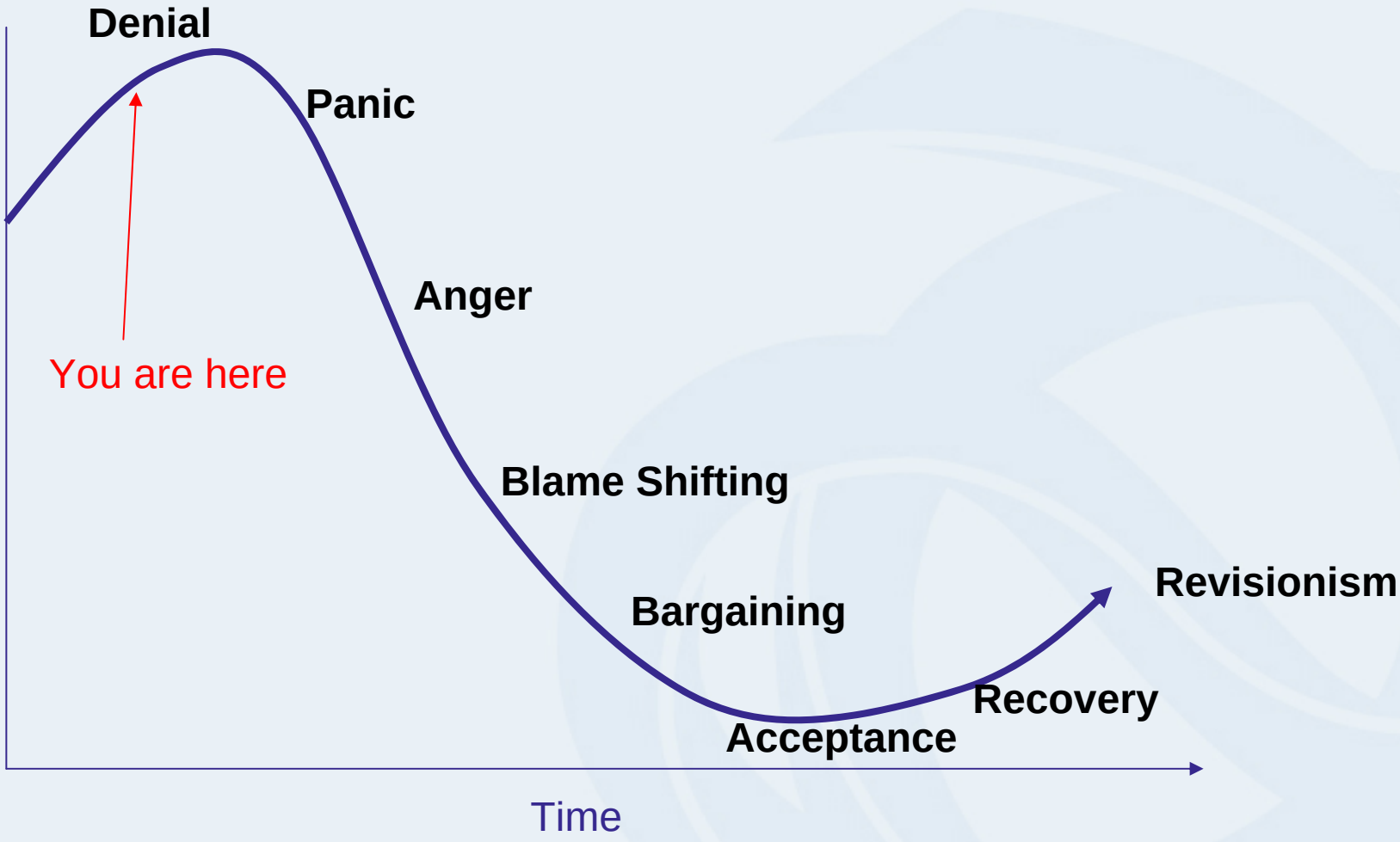
This will probably not be seamless nor costless

This should not come as a surprise to any of you

But it probably will anyway …..

Coping with Crises

Coping with Crises – IPv4 Exhaustion



Thank You