



Beyond IPv4 ?

Geoff Huston



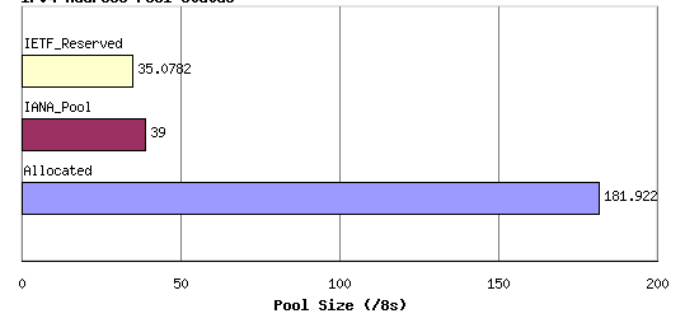
CAIA Seminar 10 July 2008 <http://caia.swin.edu.au>

Religion, Technology, Engineering

Religion, Technology, Engineering
and
The End of the world as we know it!



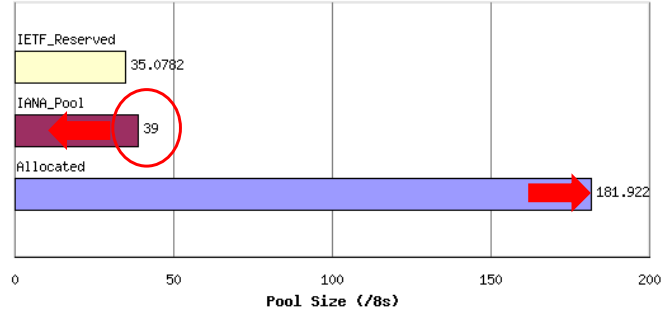
IPv4 Address Pool Status



Today

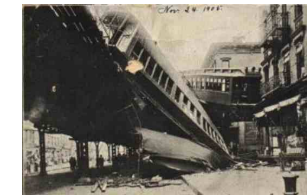


IPv4 Address Pool Status

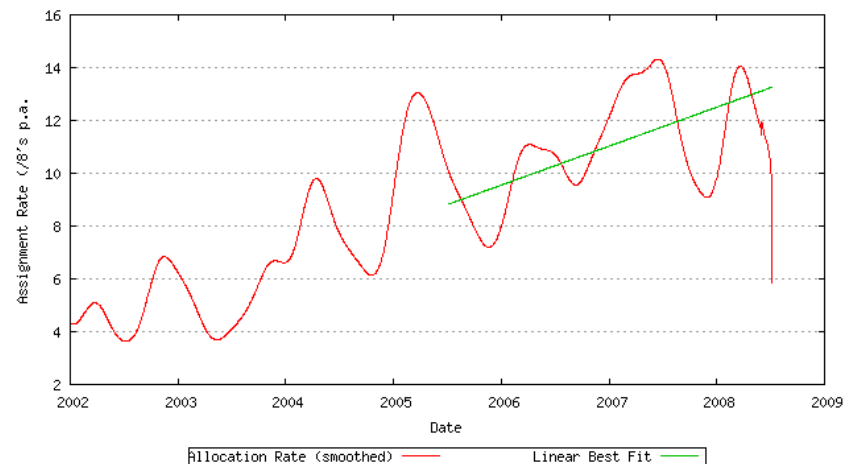


Today

RIR Address Allocation Rates



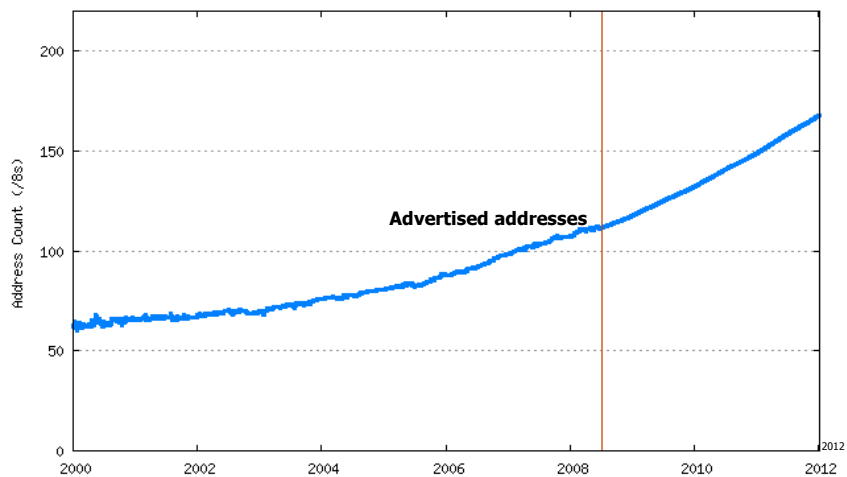
First order differential of allocations(smoothed)



Predicting Tomorrow



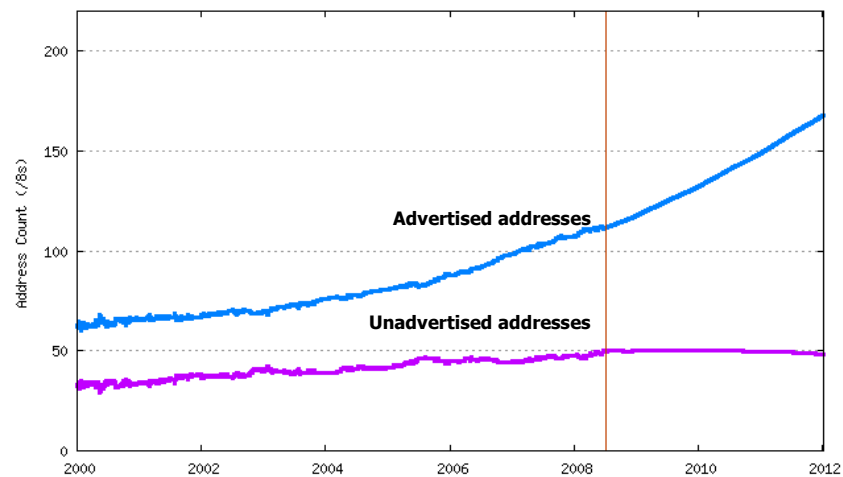
Data Prediction



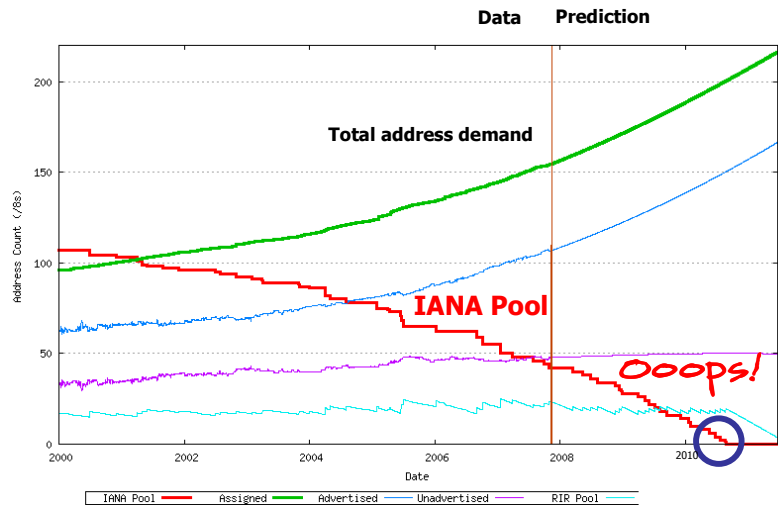
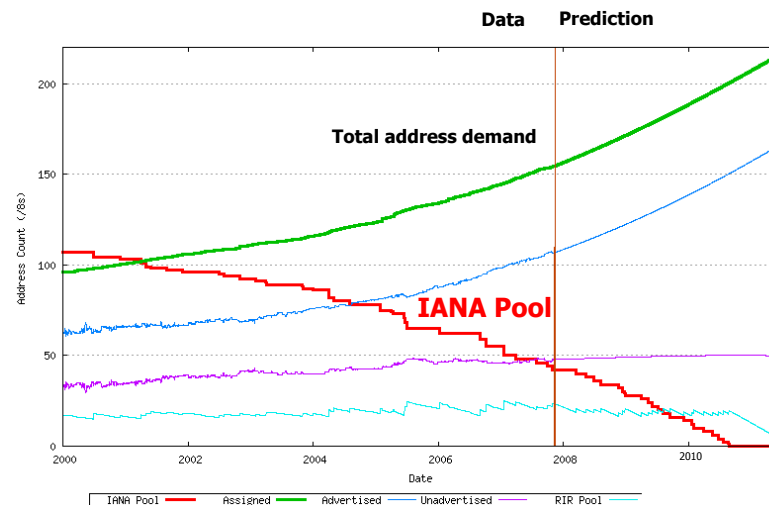
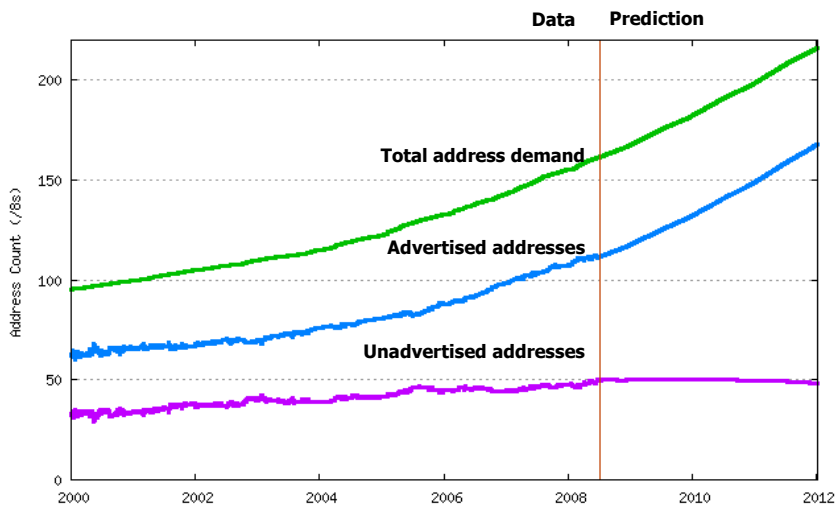
Predicting Tomorrow



Data Prediction



Predicting Tomorrow



That's 18th January 2011

<http://ipv4.potaroo.net>

That's a highly uncertain prediction - it could be out by as much as 18 months



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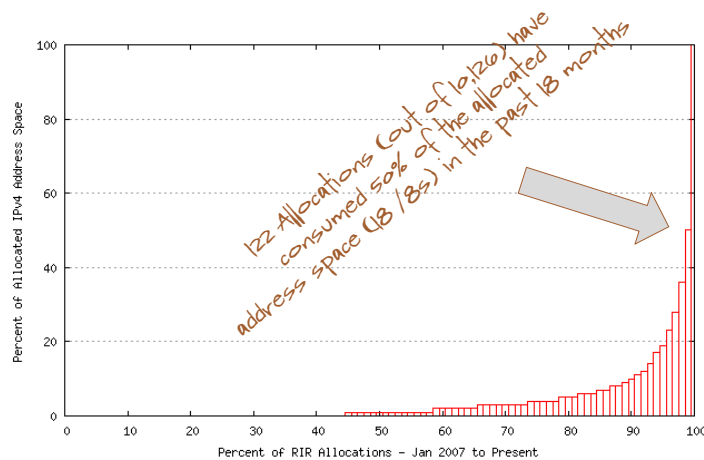


Can't model changes in demand due to:

- Panic — last minute rush
- New Policies — “reservations” of remaining address space
- Change of relative IPv4 / IPv6 demands

And modeling uncertainty due to:
highly skewed data used to make projections

That's a highly uncertain prediction - it could be out by as much as 18 months

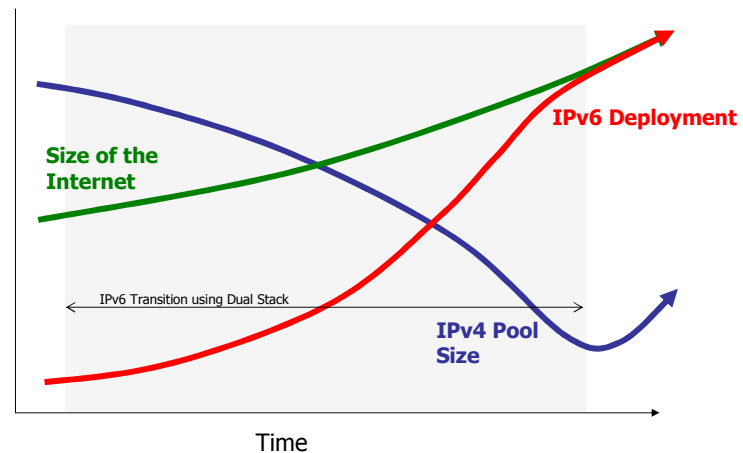


That's sometime between late 2009 and early 2011

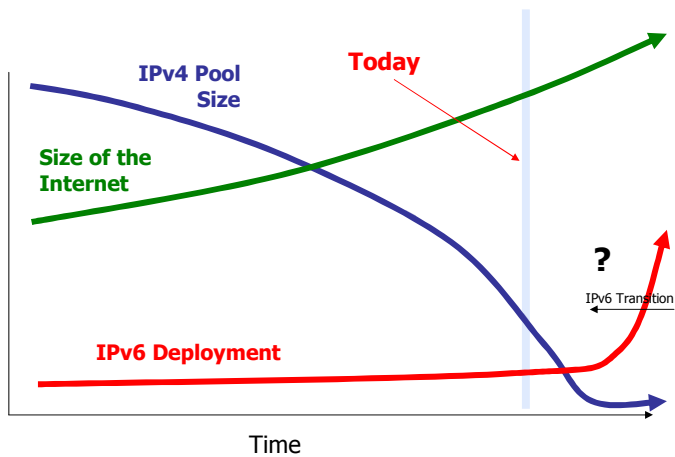


what then?

We had a plan ...



what's the revised plan?



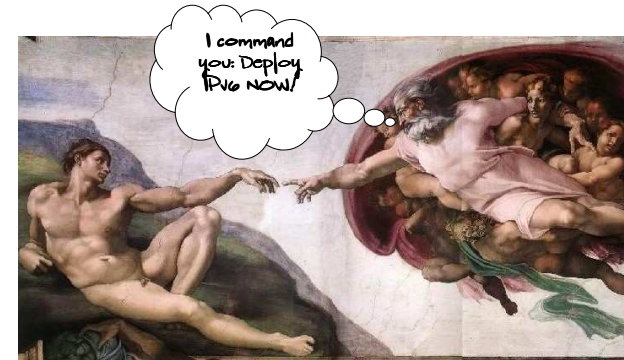


Now what?

Some possible scenarios:

- Rapid IPv6 deployment
- Persist in IPv4 networks using more NATs
- Address markets emerging for IPv4
- Routing fragmentation
- IPv6 transition

Faith ?



Scenario A:
It's simply a Matter of Faith



The "lets deploy IPv6 now!" option:

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It's simply a Matter of Faith



The "lets deploy IPv6 now!" option:

The global internet adopts IPv6 universally before January 2009 and completely quits all use of IPv4 well before address pool exhaustion

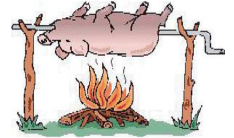
Scenario A: It's simply a Matter of Faith



The "lets deploy IPv6 now!" option:

The global Internet, with more than 1.7 billion users, a similar population of end hosts, and hundreds of millions of routers, firewalls, and billions of lines of configuration codes, and hundreds of millions of ancillary support systems, where only a very small proportion are IPv6 aware, , are all upgraded and fielded to work with IPv6 **in the next 120 days**, and completely quits all use of IPv4 in **130 days time**.

Faith and Reality



BIG and FAST don't go together!

Its Just Business:



- This entire network is customer funded
- And customers have absolutely no clue what this IPv6 stuff is about
- So they are not paying for IPv6 deployment!

New Markets for IPv6?



The Universe of Tiny Things?

The world of billions of chattering devices unleashing new rivers of gold into the IP industry?

Or is this just the economy? There is no new money and these billions of chattering devices will generate much the same revenue as we have today

So we have to cram all these billions of new devices trillions of new packets into the same money that we have today.

technology leverage will make tomorrow's networks 1,000 times CHEAPER to deliver an IP packet than today's network?

Or have we reached some limit to the economic viability of communications that imply that ever smaller valued transactions can't be sustained over ever larger networks?

Do RFID and Bluetooth provide a different model of communication that is viable in the universe of things, where the density is global but the communication is strictly limited in scope and

All if you ever are curious enough to enlarge this slide to see if there is any all the way down the page you will have got yourself to this point, where it became obvious that I've got nothing more to say and I want to fill up the bottom of the slide with tiny text.

Business Realism



So far IPv6 is a dismal business failure on the supply side

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IPv6 adoption represents the marginal benefit of a pretty minor technology change with all the costs of a major forklift upgrade

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IPv6 adoption represents the marginal benefit of a pretty minor technology change with all the costs of a major forklift upgrade

- No valuable new markets are exposed
- No incremental operator or consumer benefit
- No capability for incremental displacement of services
- No visible 'early adopter' rewards
- No high risk venture capital backing

Scenario B: IPv4 and NATs



The "lets just use more NATs" option

Can we continue to deploy more NATs to keep the Internet on IPv4 — indefinitely?

NATs on steroids



- Incremental piecemeal deployment is just too seductive to ignore!

Shift ISP infrastructure to private address realms

Multi-level NAT deployments both at the customer edge and within the ISP network

Fun new products to play with: carrier scale NATs?

New forms of product differentiation to replace the QoS debate: premium higher margin products without NAT?

Scaling NATs



Let increase our use of NATs by adding NATs into the network fabric as well as on the edges

In which case we'll need to address the following issues:

no existing products

no understanding of NAT behaviours

not enough private address space

capacity / speed of the NAT

uncertain binding table behaviours

Critical points of failure / vulnerable points of attack

NAT / DNS interaction

Application behaviour in the face of cascading NATs?

price escalation of IPv4 addresses

NAT Futures



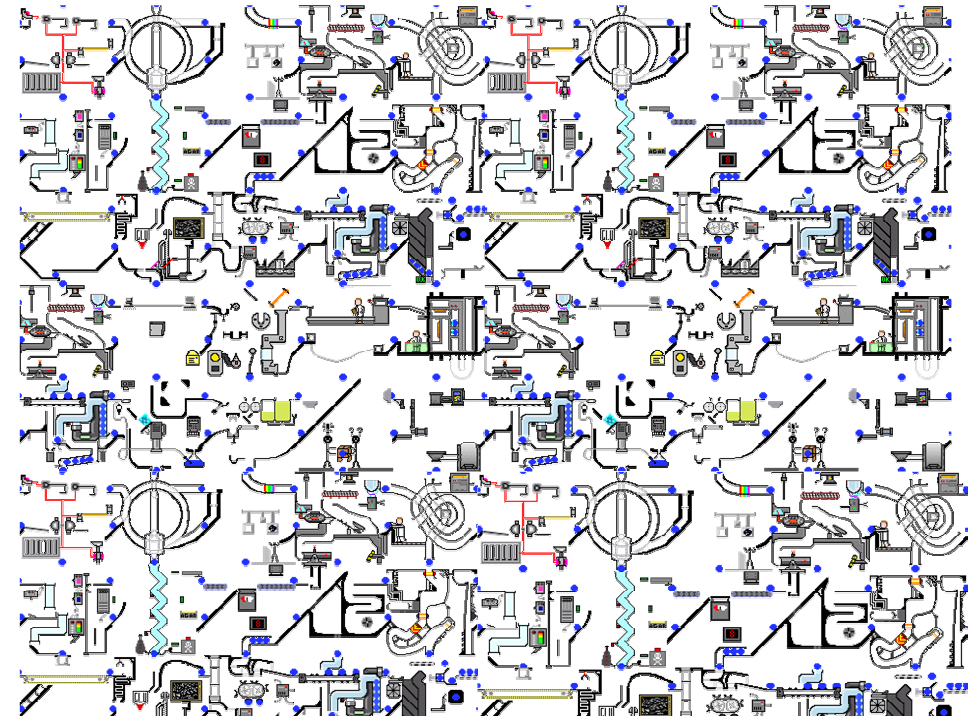
Are NATs just more of the same? Is this the "safe" option?

How far can NATs scale?

At what point do application level gateways look viable?

How complex can we get with this network?

Are we willing to find out?



Scenario C: Transition to IPv6



- IPv6 is not backward compatible with IPv4 on the wire
- There is NO IPv4 / IPv6 switch
- So its "dual stack" or nothing

Either dual stack in the host, or dual stack via protocol translating proxies

Double or Quits?



- Dual Stack transition is an "and" proposition

*It's a case of IPv4 and IPv6
Double the fun and double the cost?*

- But for how long?

So we need to stretch IPv4 out to encompass tomorrow's Internet, and the day after, and ...

Using ... NATS? ... and markets for IPv4 addresses?

Is this viable?



Will this fly, or is it just another exercise of replacing optimism over reality?

Where Are We Now?



How much IPv6 is "out there"?

Where are we now with IPv6?



Using dual-stacked web server stats as the basis of the measurement, IPv6 use is approximately 0.1% of today's Internet

which is about the same place we were four years ago

Where are we now with IPv6?

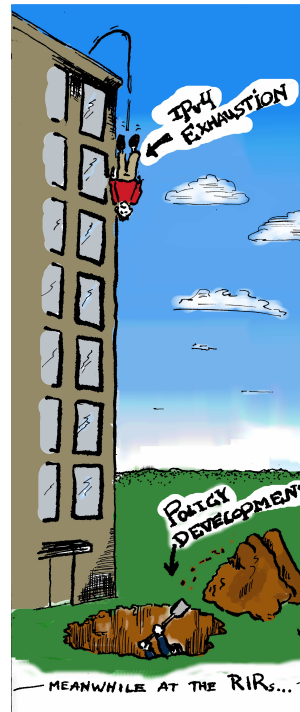


Firewalls and filters?
CPE DSL modems?
DSL product support?
AAA support?
Routing support?

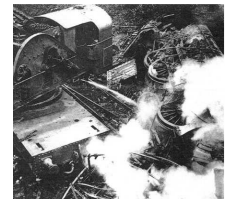
...

What Can We Expect?

Some last minute panic on the address policy side!



Making IPv4 Last Longer



- Not every address is "in use"
End host utilization levels of addresses are estimated to be around 5% - 20% of the address pool
- So could we flush more addresses back into circulation?
Yes, but you really won't like it!



What Can We Expect?

Housekeeping and Auditing of existing networks

Some cleaning out of the dusty cupboards for old unused IPv4 address space

Renumbering all NAT-covered networks into private address space to allow public IP space to be used in public networks



What Can We Expect?

Pricing of IPv4 addresses

Services that require public IPv4 addresses to attract a tariff premium

Emerging markets in IPv4 address trading as a means of redistribution of addresses between providers and corporates



What Can We Expect?

Cost pressure placed on new deployments

existing deployments sit on IPv4
no pressure to shift to dual stack!

new deployments need to support dual stack with intensive NAT and NAT-PT use to connect to IPv4 network base



What Can We Expect?

new IPv6 deployments will need NAT-PT front ends

Limited functionality

High fragility and vulnerability

DNS and Network security is blown!

What Can We Expect?



If all else fails we can use IMS to rebuild the Internet as a collection of high-walled gardens with constrained interconnection

And maybe that's precisely what some of the larger industry actors would prefer



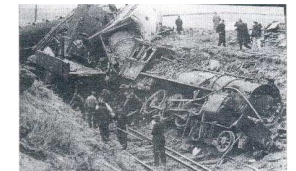
What can we do?

What could be useful right now is ...



- Clear and coherent information
- Appreciation of the broader context
- Some pragmatic workable approaches

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- Clear and coherent information
- Appreciation of the broader context
- Some pragmatic workable approaches

And an admission that failure is an option: some transitions are not 'natural' for a deregulated industry.

What should we preserve?



The Internet:

- Functionality of applications
- Viability of routing
- Capability to sustain continued growth
- Integrity of the network infrastructure

If we can!

The Fine Print



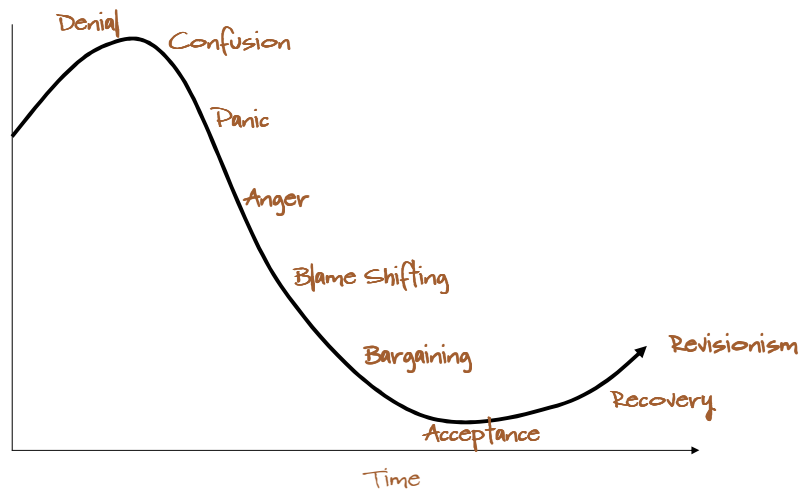
It is likely that there will be some disruptive aspects of this situation that will impact the entire industry

the original transition plan is a business failure
resolution of this failure is now going to be tough

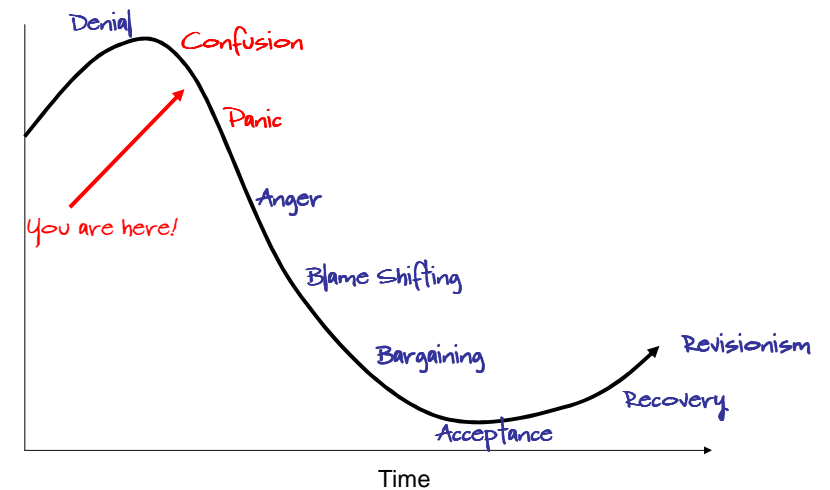
This will probably not be seamless nor costless

And will probably involve various forms of regulatory intervention, no matter what direction we might take from here

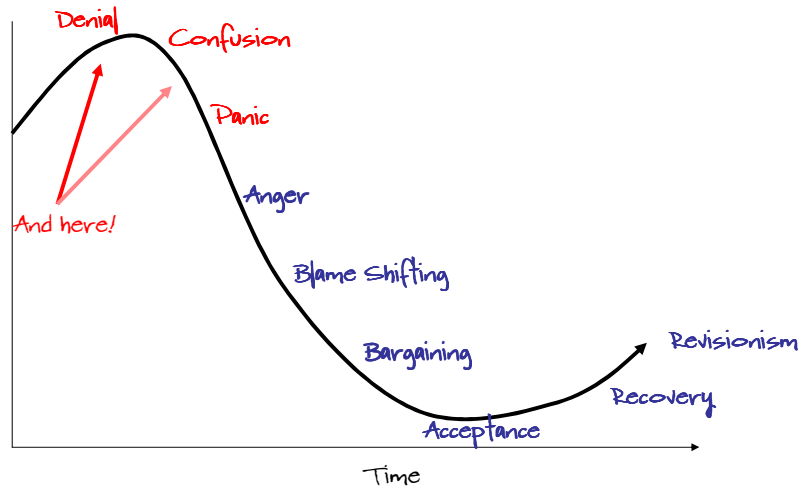
Coping with Crises



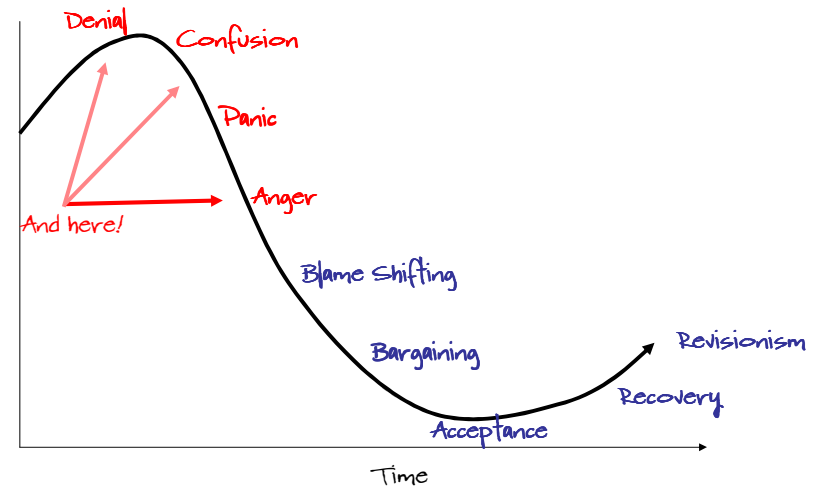
Coping with Crises



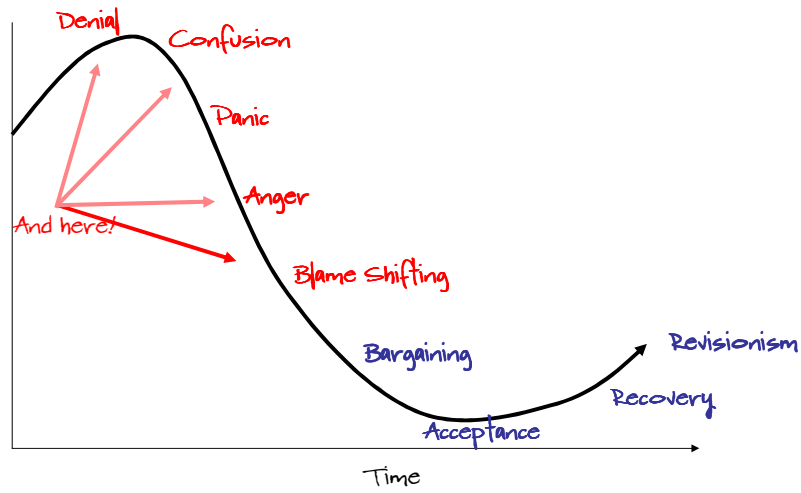
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Coping with Crises



Coping with Crises



Thank you



