

Internet Multi-Homing Problems: Explanations from Economics

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Outline

TECHNICAL

- How does Internet routing work ?
- How does multi-homing work ?
- How does SHIM6 work ?

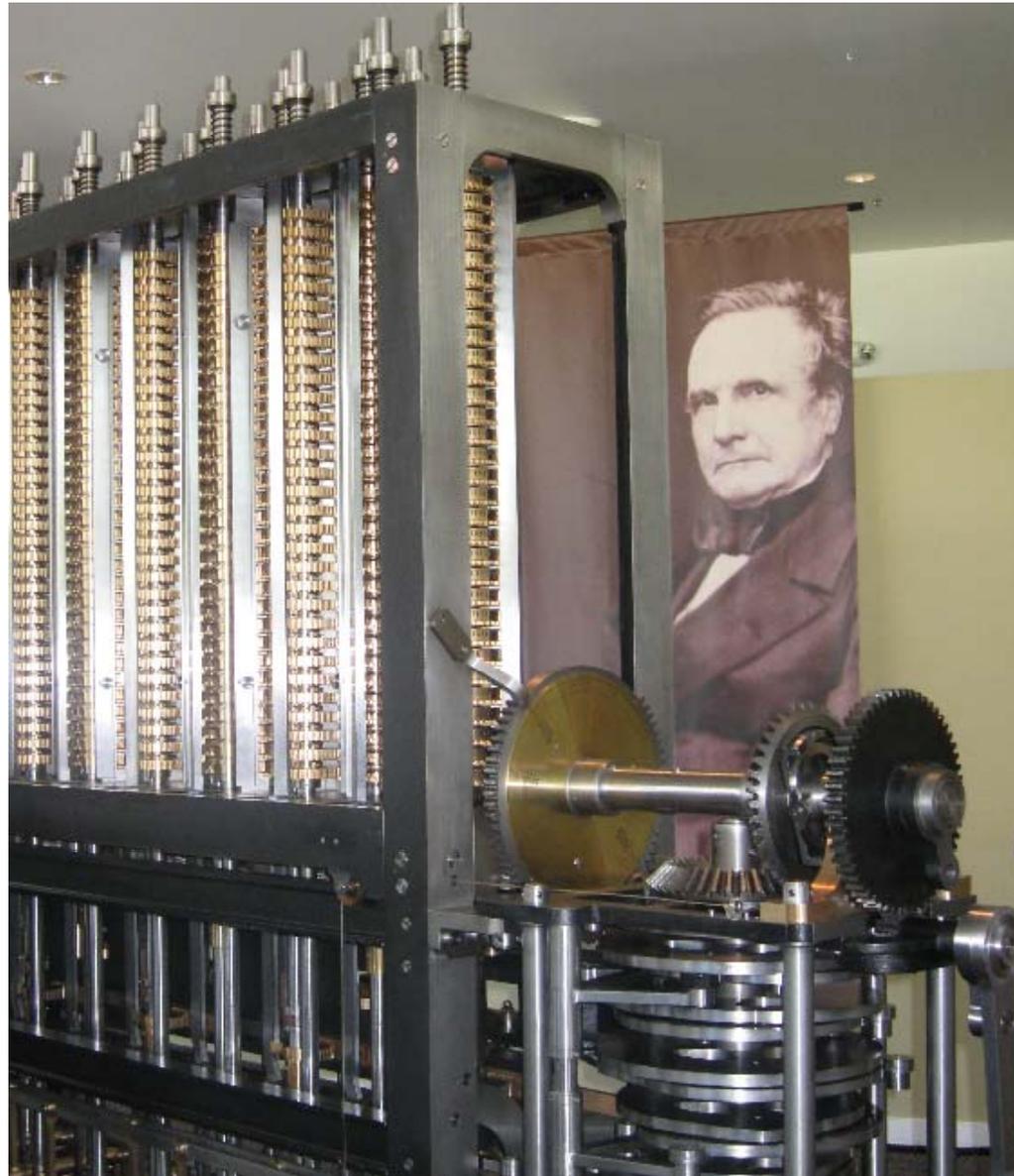
ECONOMICS

- How does Internet routing fail ?
- How does multi-homing fail ?
- How will SHIM6 fail ?

LOOKING FORWARD

- Are there any solutions ?

TECHNICAL



How does Internet routing work ? (simple view)

- Autonomous Systems (ASs) announce their routes (addresses)
 - think of "AS" as equivalent to "ISP"
- Flood fill algorithm means all routers learn everything
- Rule #1 Traffic sent to the "most specific" route
 - AS 1 announces 192.168.0.0/16
 - AS 2 announces 192.168.1.0/24
 - traffic for 192.168.1.25 sent towards AS 2
 - intended to simplify announcements
- Rule #2 Traffic sent over shortest route
 - seen from 'here' route to 192.168.1.25 is via AS 5, 4, 2
 - seen from 'here' route to 192.168.1.25 is via AS 6, 2
 - => traffic sent via AS 6
 - intended to ensure efficient routing

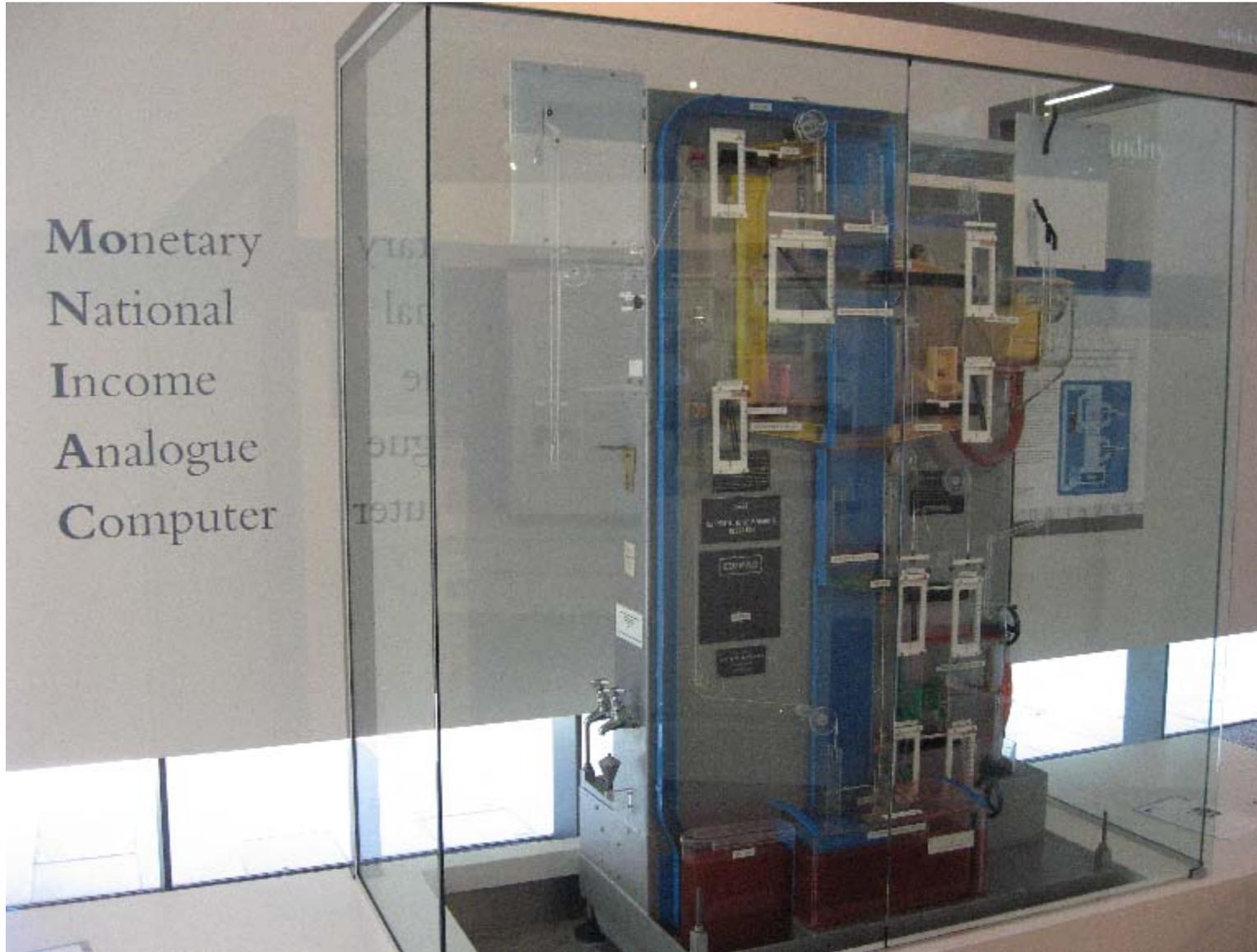
How does multi-homing work ?

- Large business determines that Internet connectivity matters
 - IP address space originally comes from ISP 'A'
 - business decides to also purchase connectivity from ISP 'B'
 - now ISP 'A' announces the route as a "more specific"
 - **and** 'B' also announces the route
- Almost always the business obtains a new AS number (not strictly needed, but seen as the 'right thing to do')
- When one connection fails traffic will flow over the other route in a prompt and uninterrupted manner
- But every router on the planet has learnt of the new AS and the two ways of reaching the address space being announced
- viz: a local decision to be more resilient has a global impact!

How does SHIM6 work ?

- SHIM6 is the chosen way of doing multi-homing in IPv6
 - chosen after lots of technical analysis of competing schemes
- SHIM6 RFCs have (very) recently been published
- Multi-homed company gets IP address space from each provider and all machines are configured to have multiple addresses
- When a long-lived connection is made to a remote machine the other end is told “if I happen to disappear, then try this alternative address instead”
 - long-lived => 20+ packets (avoid overhead for short conversation)
 - lots of extra complexity to ensure that machines do not mislead and thereby impose a denial-of-service attack on a third party

ECONOMICS



How is Internet routing failing ?

- Global routing table is growing exponentially
 - ongoing for 20 years !
- Older routers need regular replacement (or expensive upgrade)
 - run out of bandwidth to receive updates
 - run out of CPU to process updates
 - run out of RAM to hold the table
- ALSO the number of ASs is growing
 - in process of transitioning from 16-bit values to 32-bit values
- Major cause of growth is multi-homing
- Can estimate cost of each route as $\$23\text{bn} / 300000 = \77K
 - \$23bn estimate from router count & cost of different size networks
 - ALSO almost exactly twice the annual router industry sales

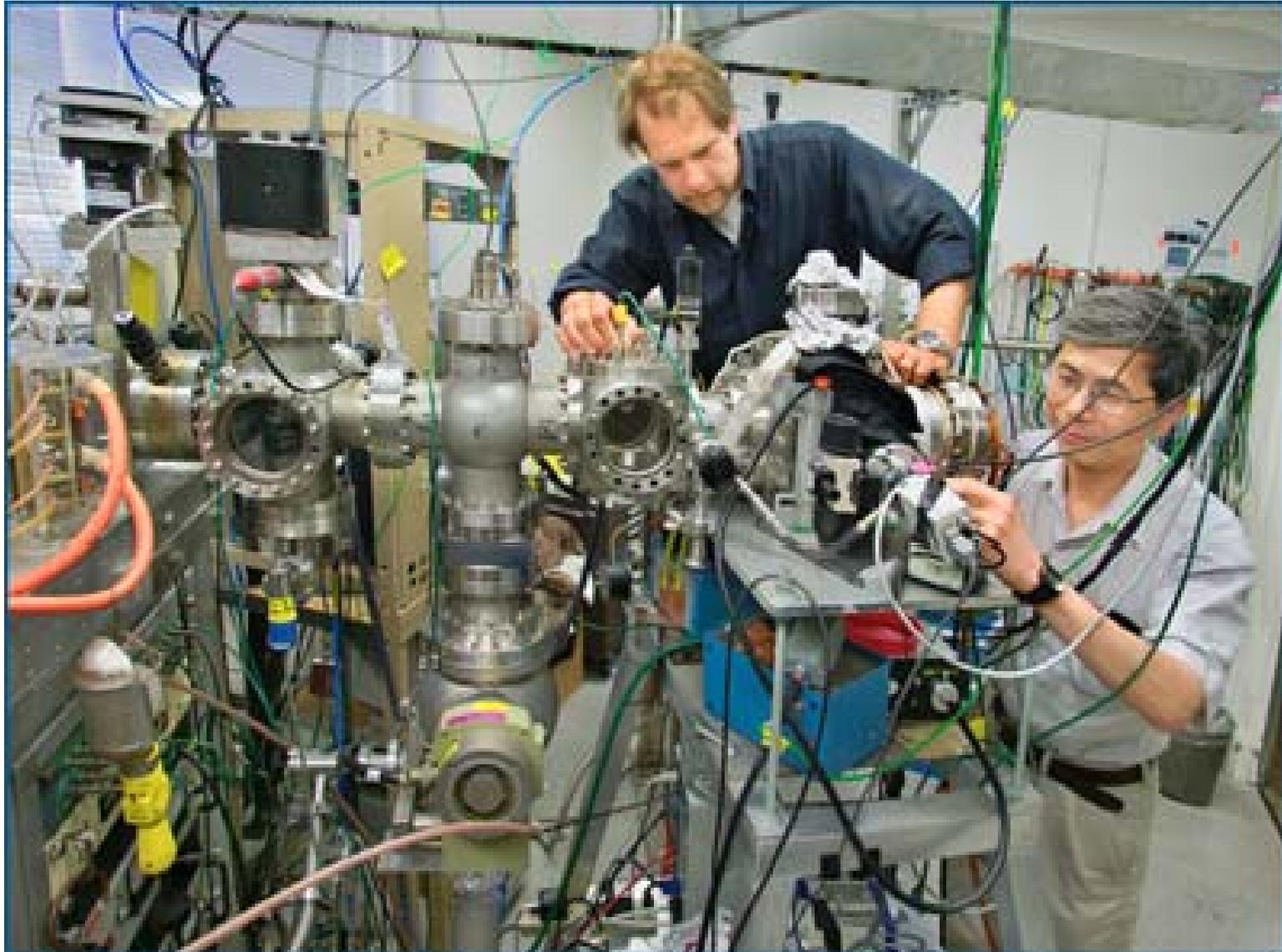
How does multi-homing fail ?

- Actual cost of obtaining an AS and publishing a route is low
- If you join RIPE in your own right
 - € 2300 in first year, € 1300 thereafter
- If your details published via ISP
 - likely to leave their RIPE subscription cost unchanged
 - in worst case, amortised rise in subs is merely a couple of Euro
- ie: local decision has global consequences
- **and** global cost is \$77K, but cost to individual business is low
- viz: a “tragedy of the commons”

How does SHIM6 fail ?

- Multi-homed IPv6 site has incentive to deploy SHIM6
 - think of this as an incentive to push suppliers for the functionality, as well as doing all the complex issues of configuration
- But site only gets a benefit if remote sites also deploy SHIM6
- These remote sites have no incentive to bother
- So to get the full benefits of being multi-homed the site needs to become an AS and announce routes in the global table
- Hence they no longer have an incentive to deploy SHIM6
- OOPS: no “first mover advantage” means no movement

Looking forward



Can we fix the problem ?

- Technically (perhaps)
 - could remove solution-space restrictions (especially assuming no co-operation between ISPs when announcing routes)
- Economically (perhaps not)
 - charge the market price for adding routes – problem is that it's hard to arrange delivery of money to right place (and hard to prevent cheating)
- Policy changes (worthwhile, IMHO)
 - anti-spam proposals have long been evaluated from economic viewpoint almost more than from technical viewpoint
 - perhaps we need an “economics considerations” added to “security considerations” within the IETF RFC process ?

Final thoughts

- Growth in global routing table driven by multi-homing
- The same problem will recur in IPv6
- SHIM6 is supposed to fix this but misaligned incentives
- Other ways of fixing this (see Ozment & Schechter WEIS2006)
 - global mandate NO
 - partial mandate NO (no obvious “tipping point”)
 - Bundling NO (unless tie to Mobile IPv6)
 - Coordination NO
 - Subsidization MAYBE
- Is this “security” – yes, availability is a security property !
- Is this economics – yes, very much so
- Is this technical – it’s still treated as such ☹

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<http://www.lightbluetouchpaper.org>



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