



# **Infrastructure, Innovation, and the Digital Divide in Asia:** *Lessons from Internet Production History*

**Version 1.0**

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**Packet Clearing House**

## **Rising official, public Interest in the Internet and Internet policy**

- Some interest predicated on sovereignty issues/claims
- 
- Some predicated on concerns about economic development, differential growth rates, e.g., the Digital Divide

## de regia non est disputandum, but...

- By definition, sovereignty issues are domain of pure politics
- 
- Issues of economics and development are different -- research, data, facts can play a useful role...

i.e., only 50% politics...

# The Internet routing table: A rich resource for policy research

Digital Divide often defined in terms of asymmetrical growth in:

**Users**



*i.e., subscribers,  
opportunistic users*

**Usage**



*i.e., time online,  
multiple access methods*

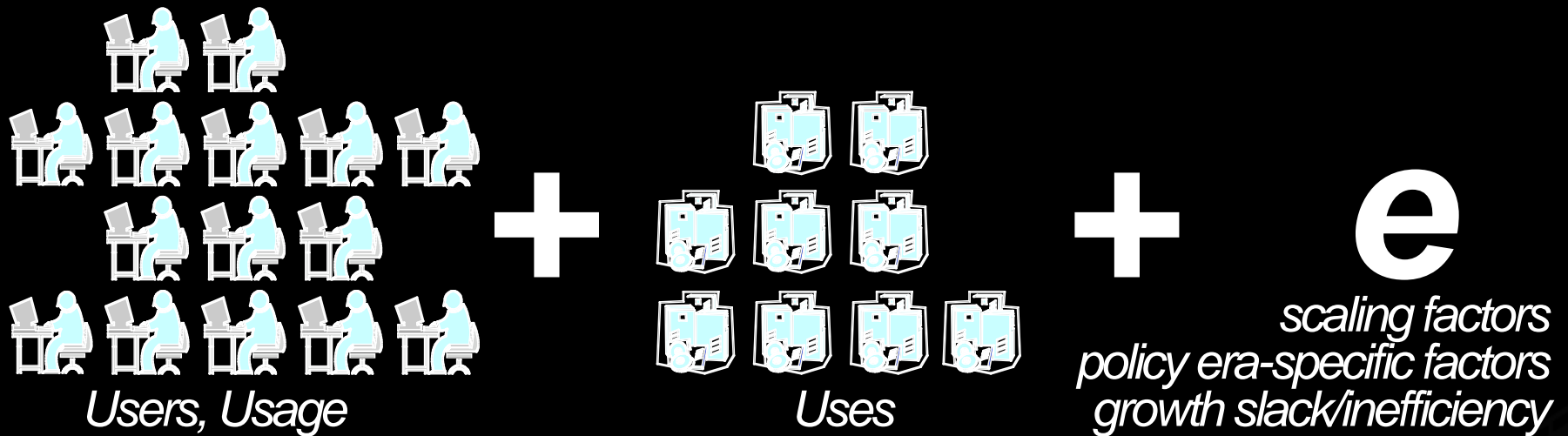
**Uses**



*i.e., diversity of content  
and services...and value*

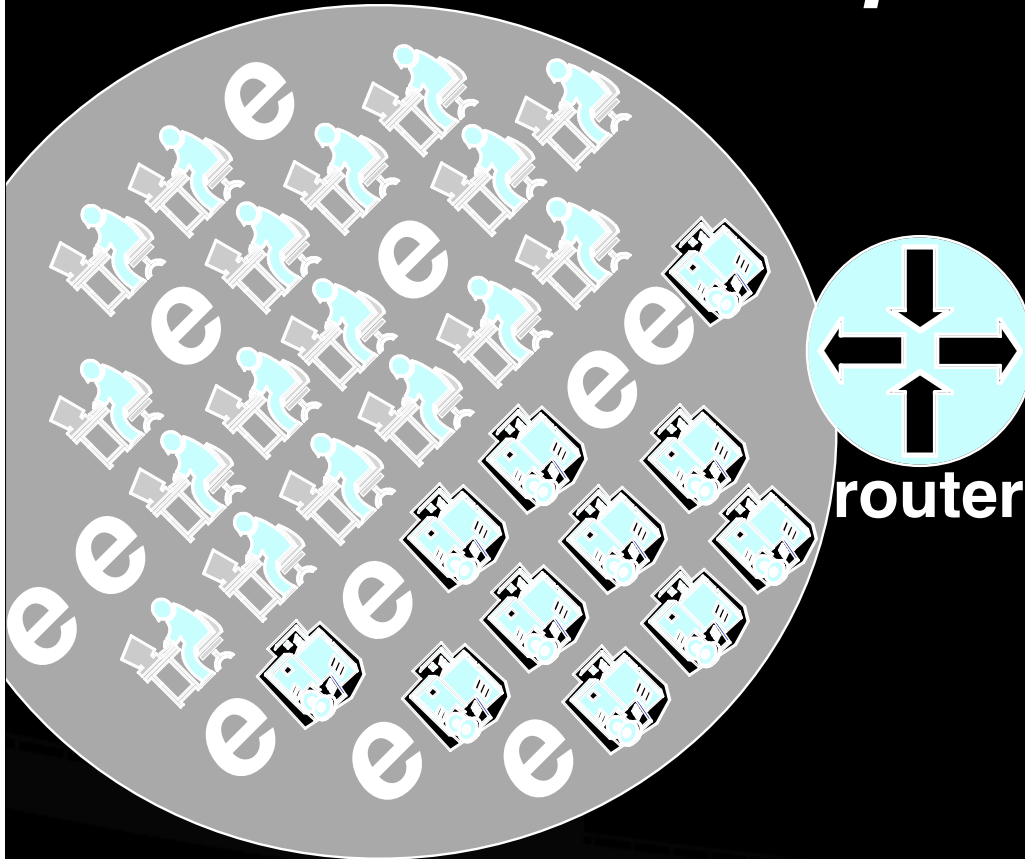
...with “asymmetry” defined by means of national comparisons

# Internet routing table(s) informs these questions in the aggregate(s)



**= IP addresses injected into the Internet routing table by an individual ISP/network operator**

# Where to count *Internet production?*



Each router connected maintains a local view of paths leading to every Internet resource

Each of those views may vary substantially in almost every way -- except one:

*All will share a common view of the **AS** of origination for each Internet resource\**

**Autonomous System**

# How to count Internet production?

**AU**

**VN**

Each Autonomous System (AS) can be associated with a national jurisdiction of ownership/ administration. It is plausible that each of those views may vary substantially in almost every way except one: the origin of the Internet traffic.

All will  
view  
orig  
Inte

**Autonomous System**

Summed production of national ASes  
= National Internet Production

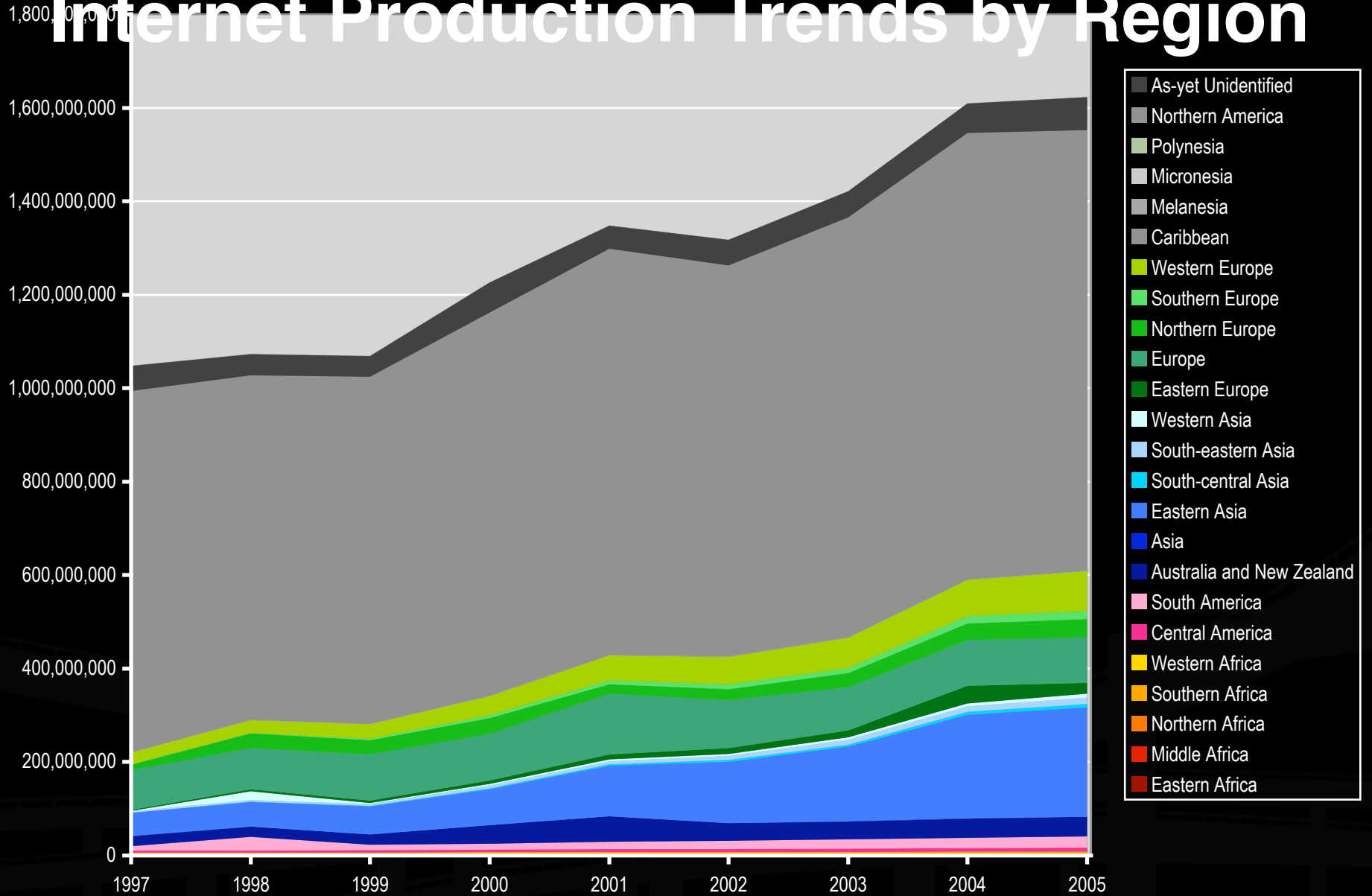
**JP**

# Internet production - who's counting?

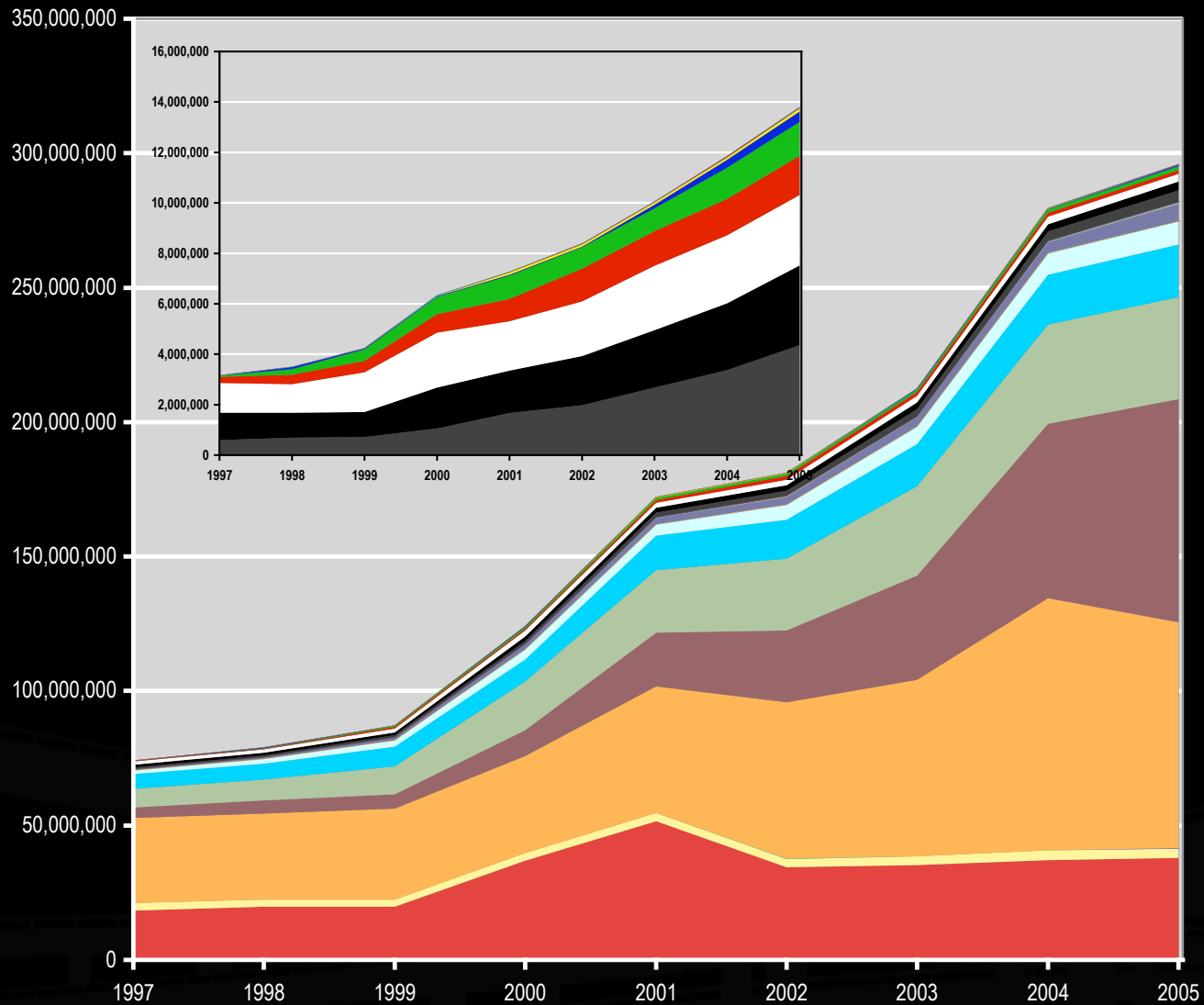
- **University of Oregon Route Views Project**  
Centralized collection of “global” routing table snapshots from multiple vantage points, 1997-present
- **Packet Clearing House**  
Local capture of partial routing tables from 40+ Internet Exchange Points around the world
- **Tony Bates, Philip Smith, Geoff Huston/APNIC, CAIDA...**  
Focus on scarce protocol resource husbandry, efficiency of route aggregation, bogon detection/remediation
- **CAIDA IPv4 BGP Geopolitical Analysis**  
Single snapshot of international distribution of Internet resources, June 11, 2001



# Internet Production Trends by Region



# Internet Production in Asia



- MYANMAR
- LAO PDR
- CAMBODIA
- BRUNEI
- VIET NAM
- PHILIPPINES
- INDONESIA
- SINGAPORE
- THAILAND
- MALAYSIA
- BRITISH INDIAN OCEAN
- MALDIVES
- AFGHANISTAN
- BHUTAN
- NEPAL
- BANGLADESH
- SRI LANKA
- PAKISTAN
- INDIA
- AMERICAN SAMOA
- SAMOA
- COOK ISLANDS
- FRENCH POLYNESIA
- MICRONESIA
- PALAU
- NORTHERN MARIANAS
- GUAM
- VANUATU
- FIJI
- MONGOLIA
- MACAU
- HONG KONG
- TAIWAN
- KOREA
- CHINA
- JAPAN
- NEW CALEDONIA
- PAPUA NEW GUINEA
- NEW ZEALAND
- AUSTRALIA

# So what? What does it mean? How much Internet production *should* there be?

Q: Internet's "end-to-end" nature often cited -- where does one find logical *ends* in the physical world?

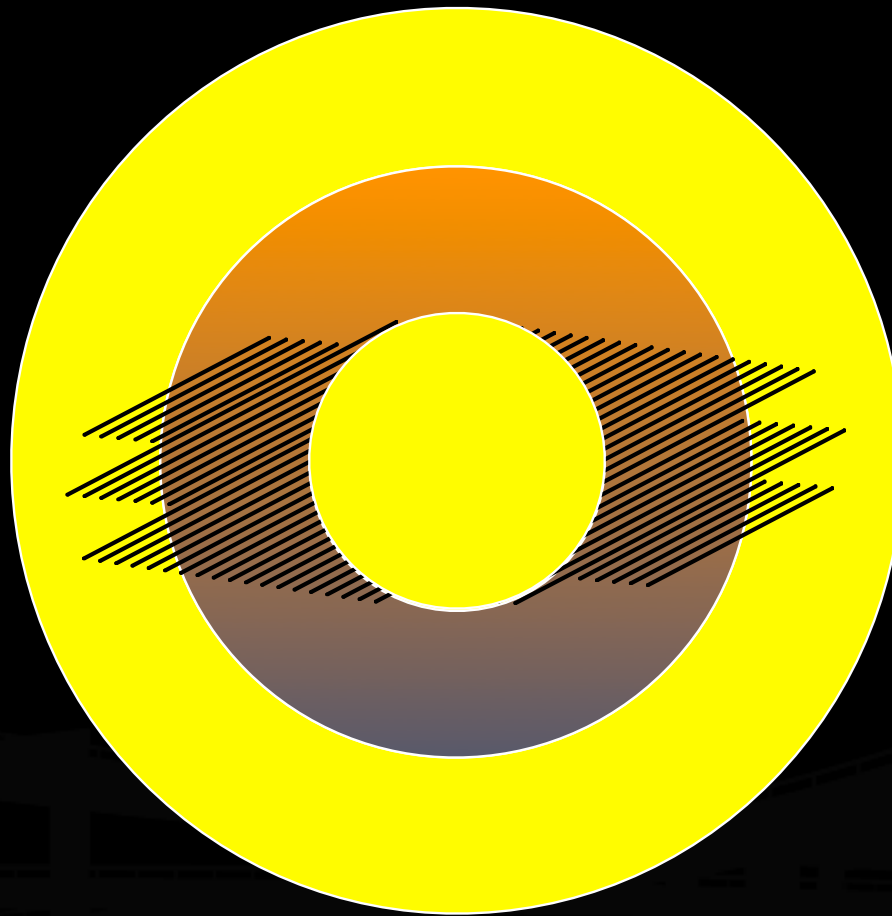
A: On interfaces of devices connected to physical media -- copper, coax, fiber -- that **enable/embody** Internet users, usage, uses...

# Physical media -- the big picture

**Copper**

**Fiber**

**Coax**



*e.g., dial (users)...  
DSL (usage)...*

*First enterprise (uses)  
then international...*

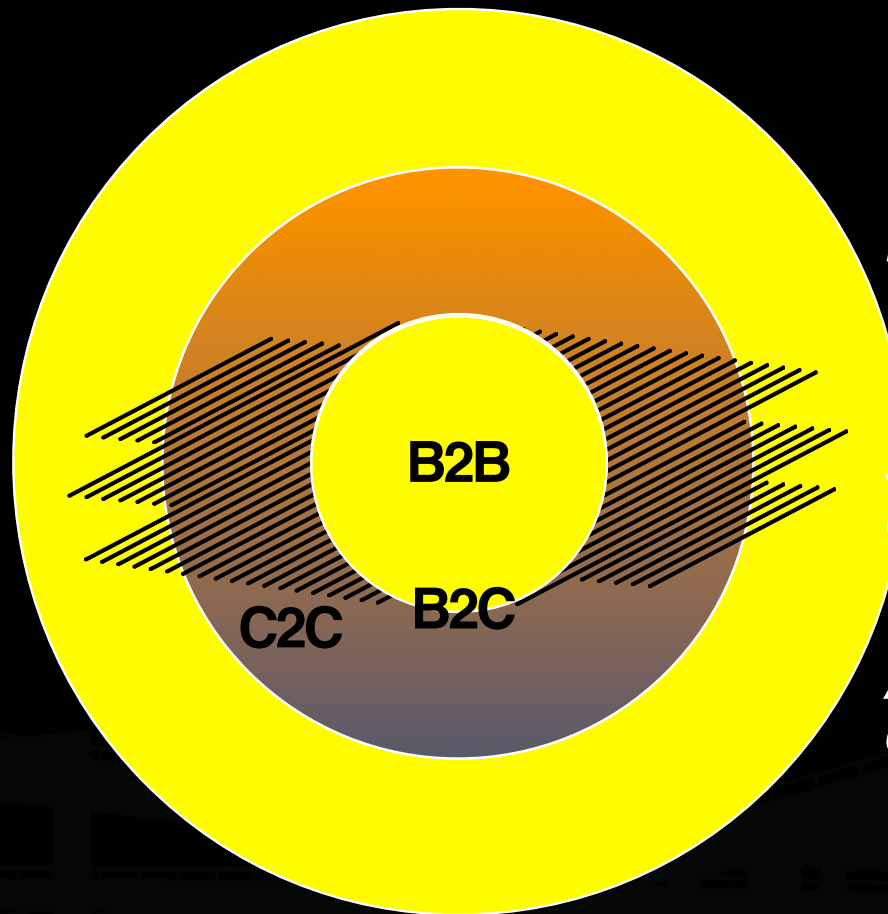
*More users, usage...*

# Physical media -- the historical view: *a coincidence of technology and policy*

**Copper**

**Fiber**  
*multiplexing*

**Coax**



*Legacy infrastructure...  
wholesale access...*

*"Value-added" services,  
separation of core/long  
distance from access,  
wholesale capacity...*

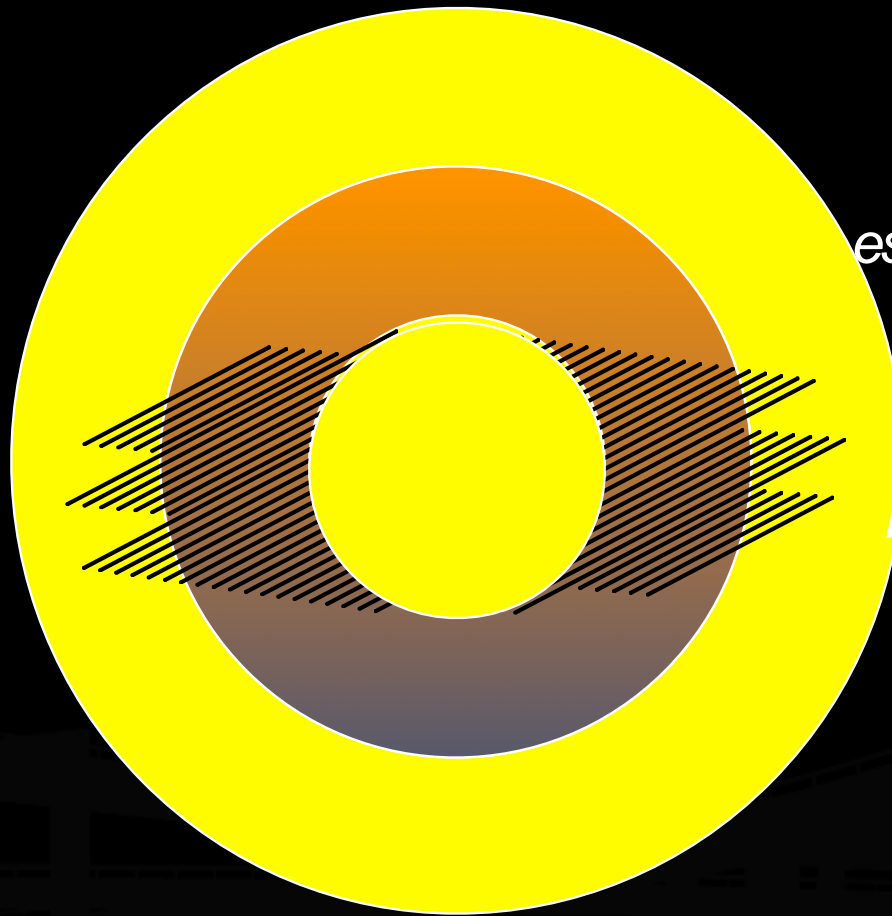
*Access segment  
competition (for some)...*

# Physical media -- the stakes: significance of access

**Copper**

**Fiber**

**Coax**

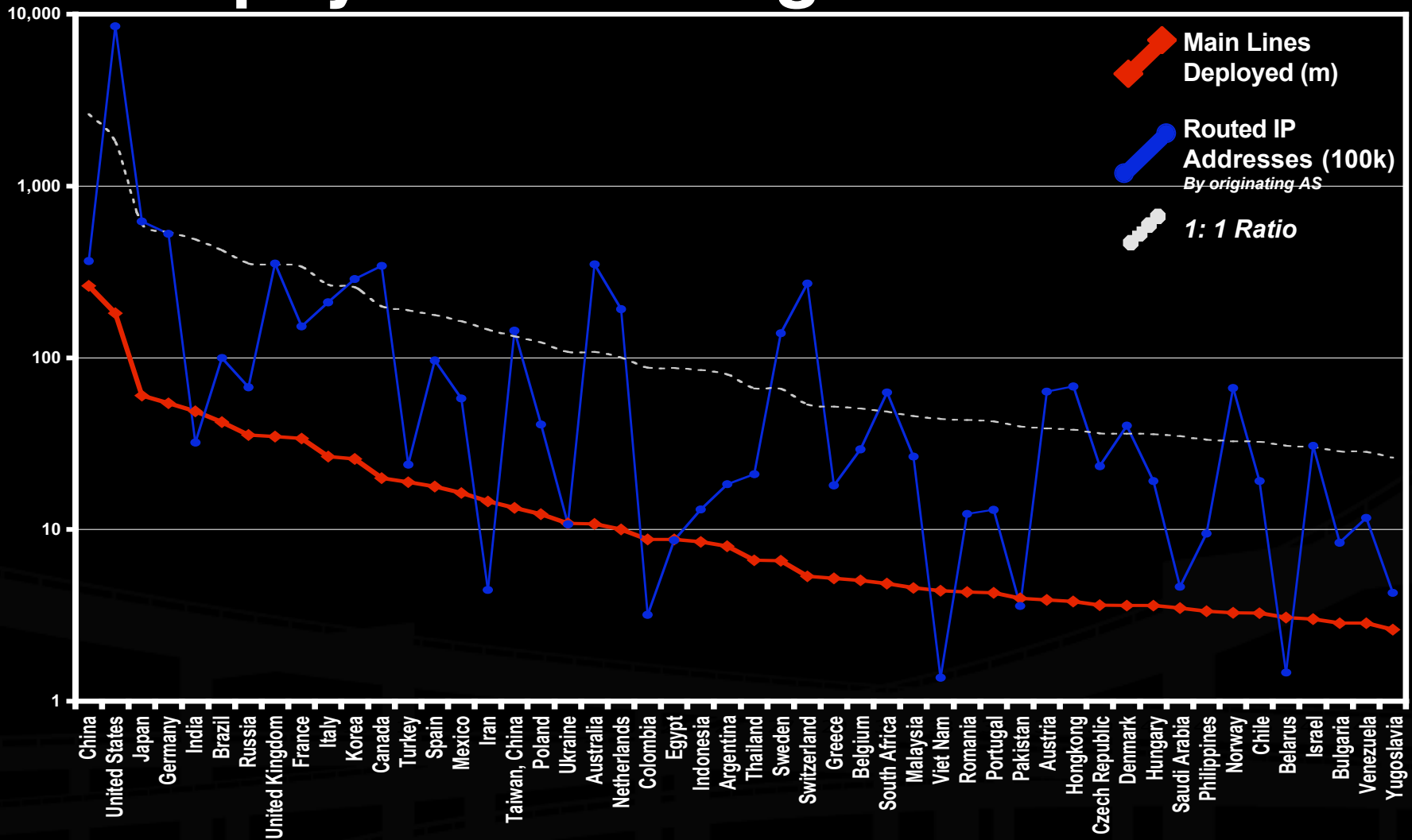


*est. 9 billion miles in high density areas c. 2003*

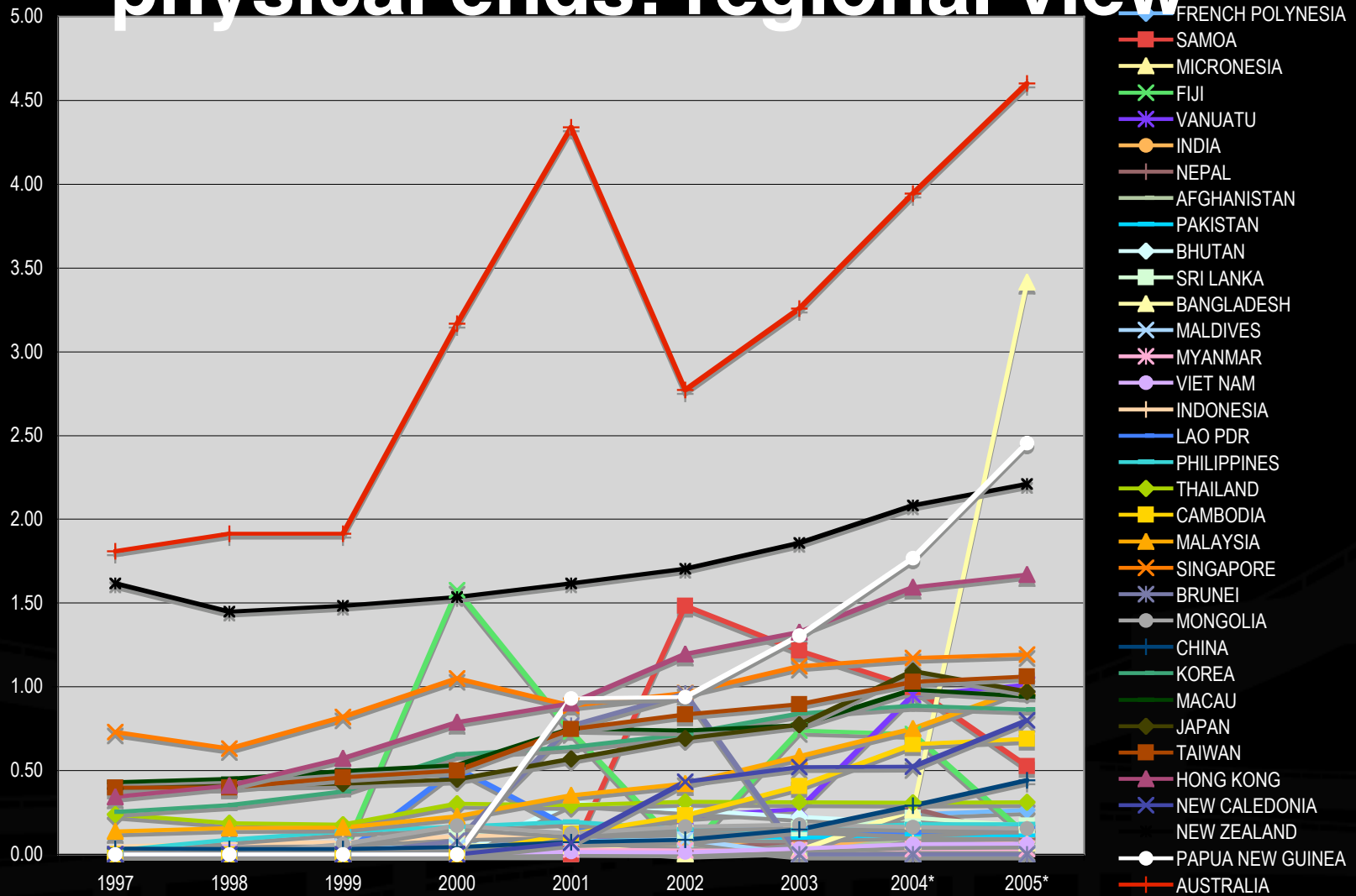
*Maybe 1 billion unduplicated miles, much idle/underutilized*

*est. 900 million miles deployed c. 2003*

# Measuring logical ends against physical ends: global view

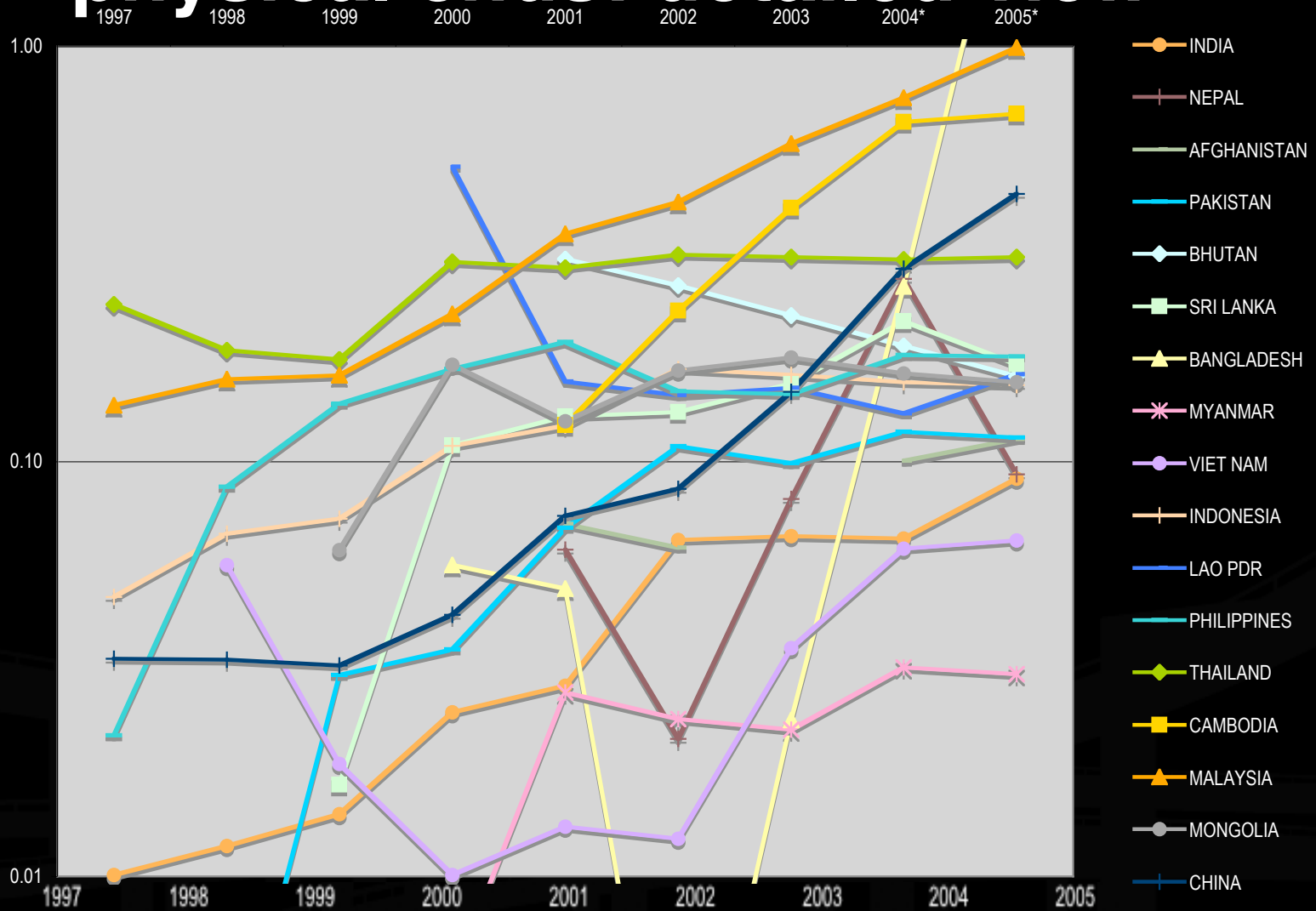


# Measuring logical ends against physical ends: regional view



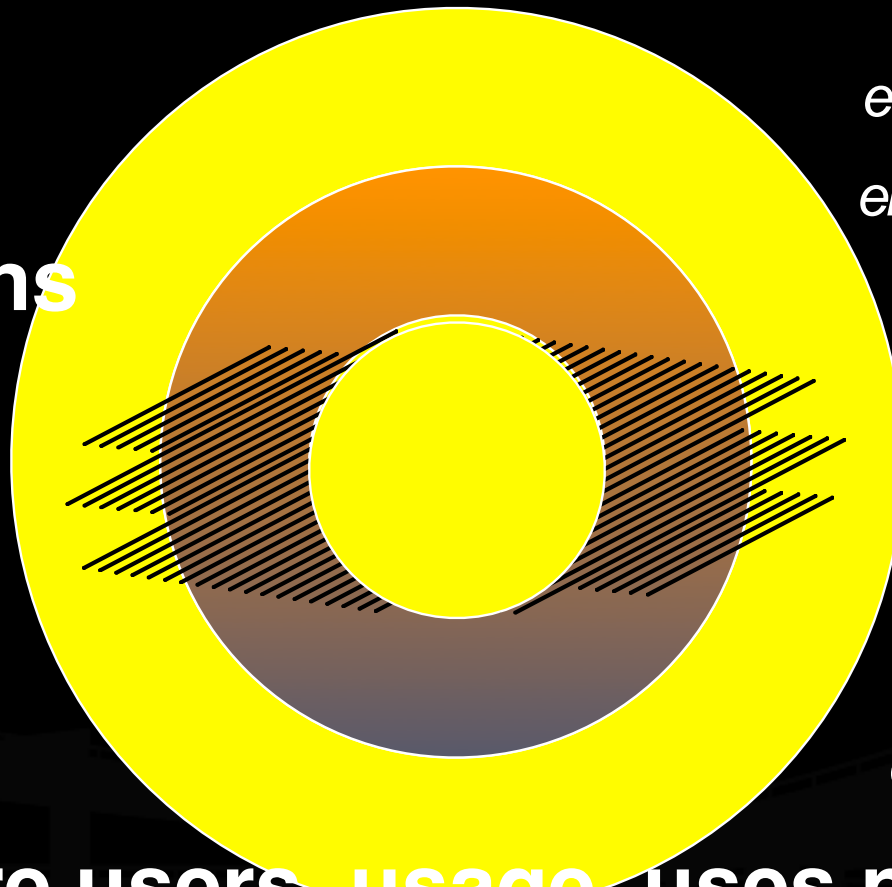


# Measuring logical ends against physical ends: detailed view



# What drives logical / physical utilization rates?

**Building efficient connections across distinct media, market segments**



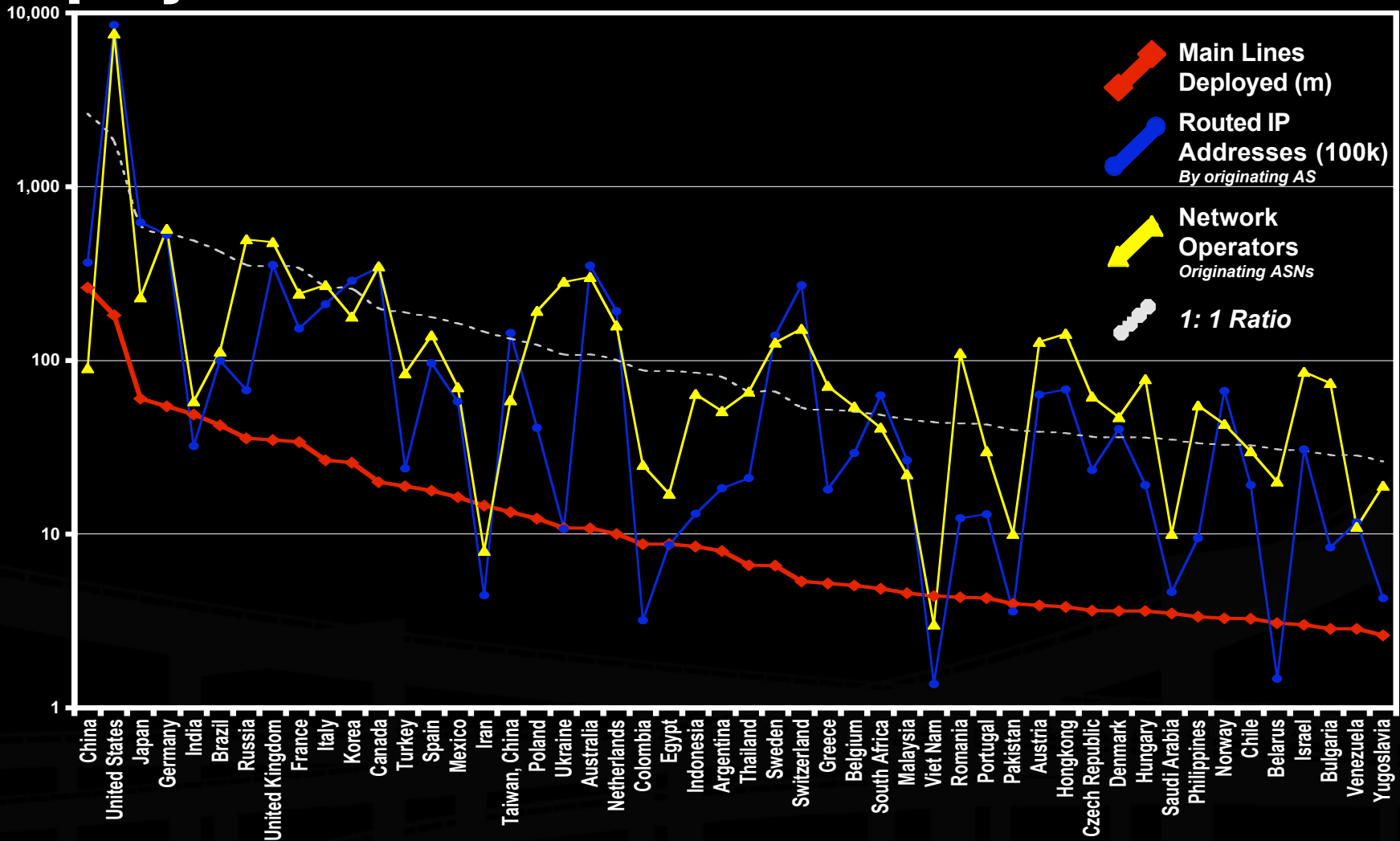
*e.g., availability of (vast) wholesale capacity to enterprises...freedom of interconnection...*

*e.g., availability of (non-duplicable) wholesale access to non-facilities builders*

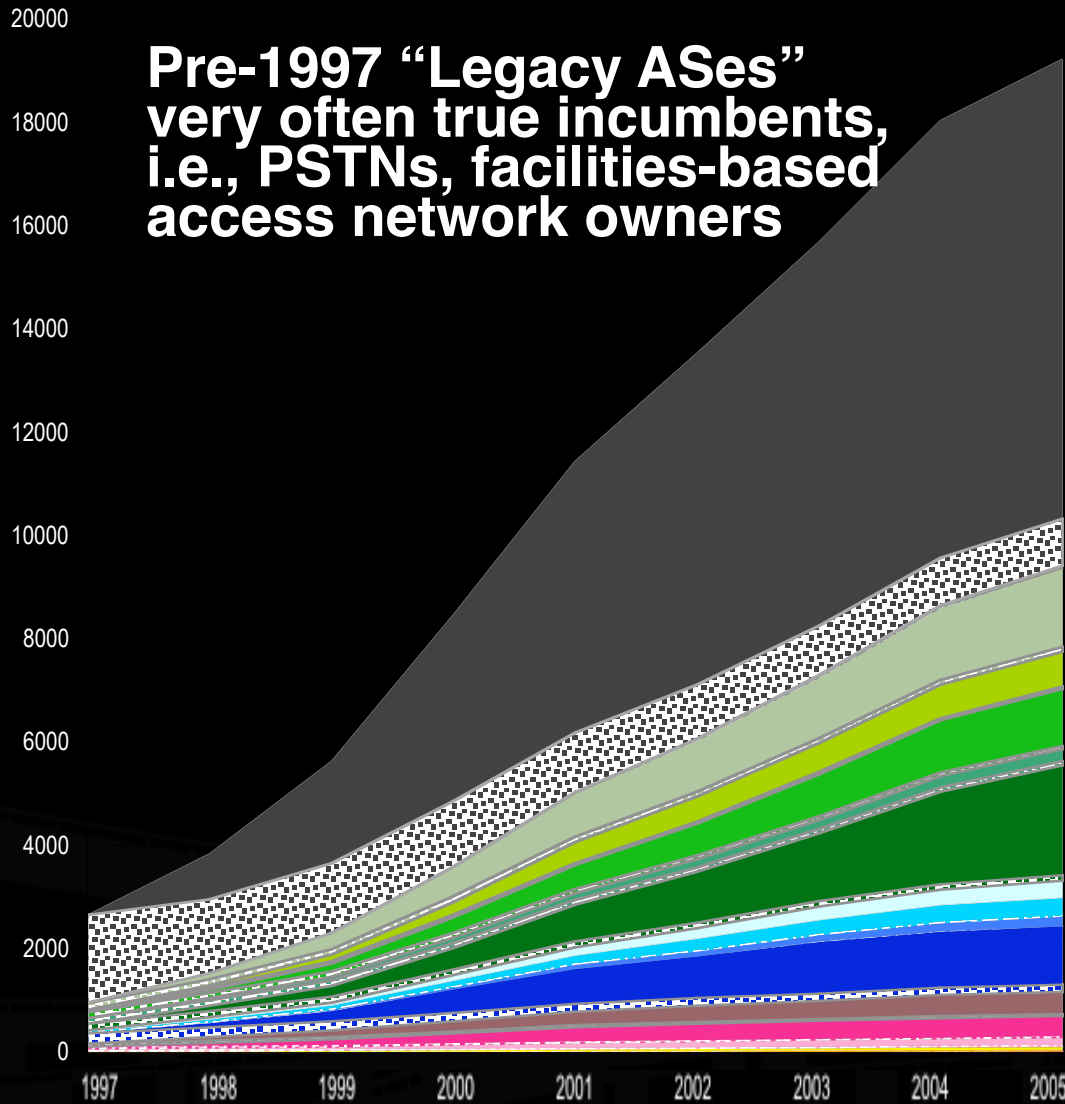
*e.g., regulatory parity across media to promote technology-driven design choices*

**-> More users, usage, uses per unit of infrastructure investment**

# Measuring logical ends against physical ends: the ASN connection

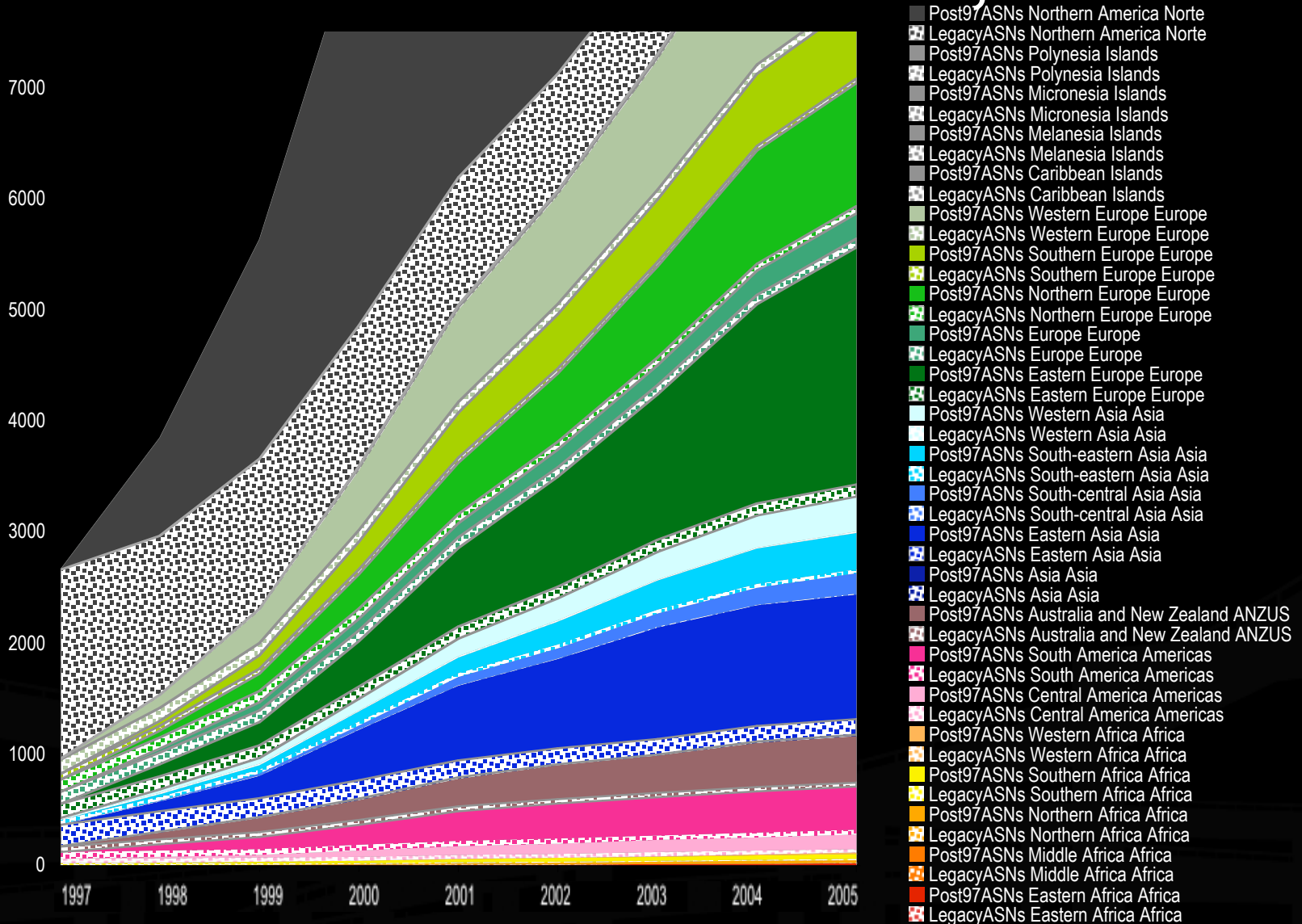


# Investigation 1: new networks since 1997



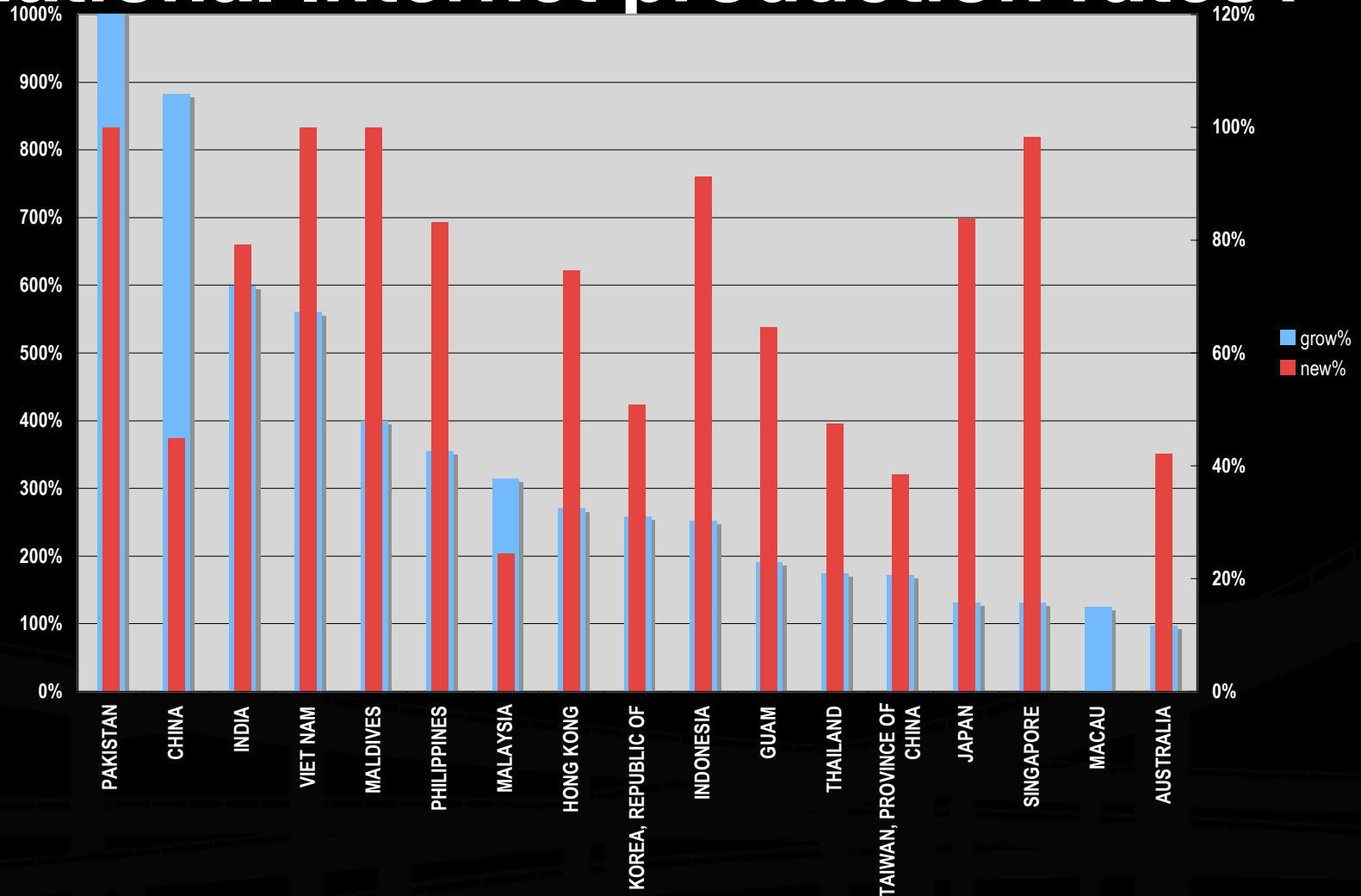
- Post97ASNs Northern America Norte
- ▨ LegacyASNs Northern America Norte
- Post97ASNs Polynesia Islands
- ▨ LegacyASNs Polynesia Islands
- Post97ASNs Micronesia Islands
- ▨ LegacyASNs Micronesia Islands
- Post97ASNs Melanesia Islands
- ▨ LegacyASNs Melanesia Islands
- Post97ASNs Caribbean Islands
- ▨ LegacyASNs Caribbean Islands
- Post97ASNs Western Europe Europe
- ▨ LegacyASNs Western Europe Europe
- Post97ASNs Southern Europe Europe
- ▨ LegacyASNs Southern Europe Europe
- Post97ASNs Northern Europe Europe
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- Post97ASNs Europe Europe
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- Post97ASNs Eastern Europe Europe
- ▨ LegacyASNs Eastern Europe Europe
- Post97ASNs Western Asia Asia
- ▨ LegacyASNs Western Asia Asia
- Post97ASNs South-eastern Asia Asia
- ▨ LegacyASNs South-eastern Asia Asia
- Post97ASNs South-central Asia Asia
- ▨ LegacyASNs South-central Asia Asia
- Post97ASNs Eastern Asia Asia
- ▨ LegacyASNs Eastern Asia Asia
- Post97ASNs Asia Asia
- ▨ LegacyASNs Asia Asia
- Post97ASNs Australia and New Zealand ANZUS
- ▨ LegacyASNs Australia and New Zealand ANZUS
- Post97ASNs South America Americas
- ▨ LegacyASNs South America Americas
- Post97ASNs Central America Americas
- ▨ LegacyASNs Central America Americas
- Post97ASNs Western Africa Africa
- ▨ LegacyASNs Western Africa Africa
- Post97ASNs Southern Africa Africa
- ▨ LegacyASNs Southern Africa Africa
- Post97ASNs Northern Africa Africa
- ▨ LegacyASNs Northern Africa Africa
- Post97ASNs Middle Africa Africa
- ▨ LegacyASNs Middle Africa Africa
- Post97ASNs Eastern Africa Africa
- ▨ LegacyASNs Eastern Africa Africa

# Investigation 1: new networks since 1997, detail





# Do strong incumbents impact overall national Internet production rates?



## Implications?

....still highly speculative

- Proliferation of ASes as consequence/  
indicator of efficient domestic wholesale  
capacity market structure
- 
- Growth in Internet production without  
corresponding proliferation of ASNs may  
be indicative of inefficient infrastructure  
bottlenecks
- 
- Digital Divide likely to close farthest/fastest  
where production of users, uses, usage  
straddles all segments



## Implications?

....less speculative I think

- *Operationally informed analysis/ comparison of physical and logical network elements -- essential to engagement with many current regional, global policy challenges...*
- *Operationally informed historical analysis of Internet routing table, coupled with natural language interpretation of Internet production -- a useful way to talk past the *Bellhead-Nethead* divide...*



# Questions...thanks!

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