

FRNOG 2006:
Internet Exchange Point
Update

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Tools for thinking about Internet Exchanges in economic terms

What are we, as ISPs, selling?

The right to modulate bits.

That right is a perishable commodity.

Where do we get the potentially-modulatable bits?

The right to modulate bits

Any Internet connection is a serial stream of time-slices.

Each time-slice can be modulated with a binary one or zero, one bit.

Each customer purchases potentially-modulatable bits at some rate, for example, 2mbps, which is 5.27 trillion bits per monthly billing cycle.

That's a perishable commodity

The quality (as opposed to quantity-per-time) characteristics of an Internet connection are *loss, latency, jitter, and out-of-order delivery*.

Loss increases as a function of the number and reliability of components in the path, and the amount of contention for capacity.

Latency increases as a function of distance, and degree of utilization of transmission buffers by competing traffic sources.

Jitter is the degree of variability in loss and latency, which negatively affects the efficacy and efficiency of the encoding schemes which mitigate their effects. Jitter increases relative to the ratio of traffic burstiness to number of sources.

Out-of-order delivery is the portion of packets which arrive later than other, subsequently-transmitted packets. It increases as a function of the difference in queueing delay on parallel paths.

All of **these properties become worse with time and distance**, which is a reasonable definition of a perishable commodity.

So where do we get the bits?

The value of the Internet is communication.

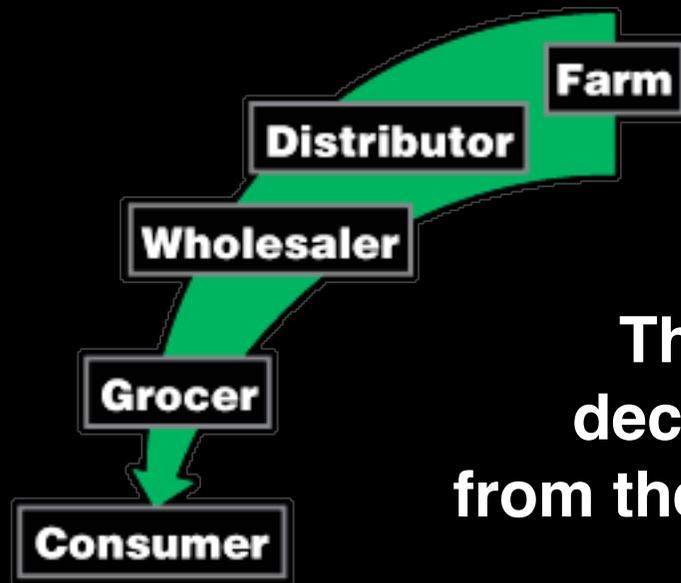
The value is produced at the point at which communication occurs between two ISPs, and it is transported to the customers who utilize it.

Thus, all the bits we sell come from an Internet exchange, whether nearby, or far away.

An analogy

Let's look at another perishable commodity with more readily observed economic properties...
Fruit.

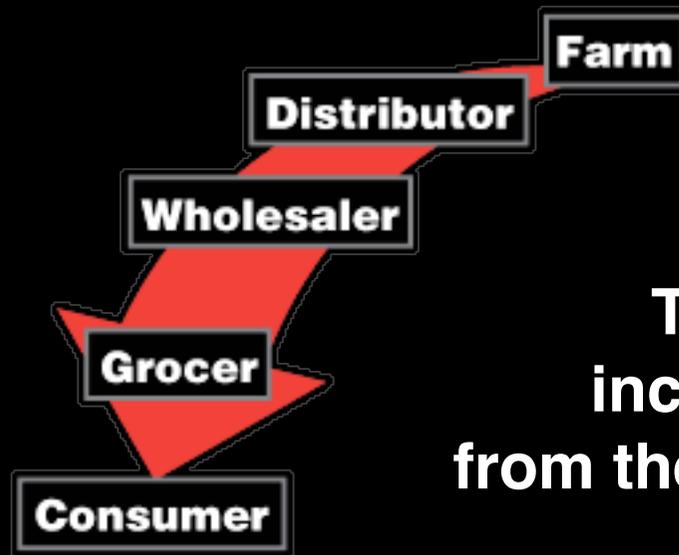
Value decreases with time & distance



The **value** of a piece of fruit decreases, the further it gets from the farm which produced it.

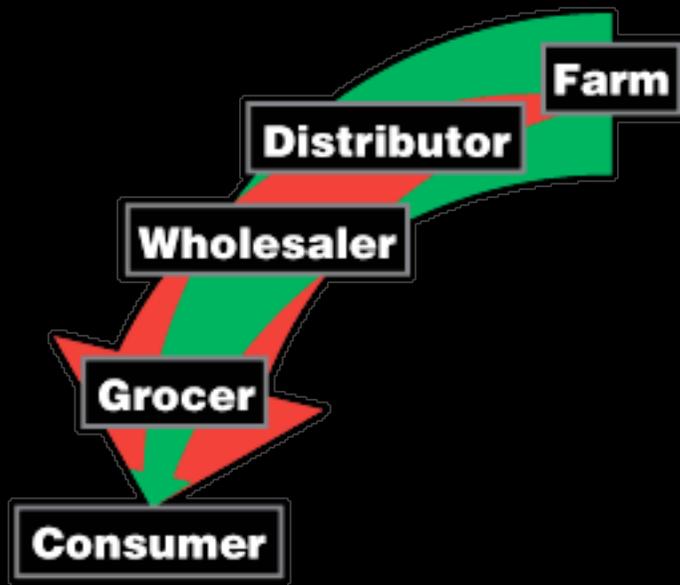
The shelf-life which the consumer can expect decreases, and eventually it becomes overripe, then rotten.

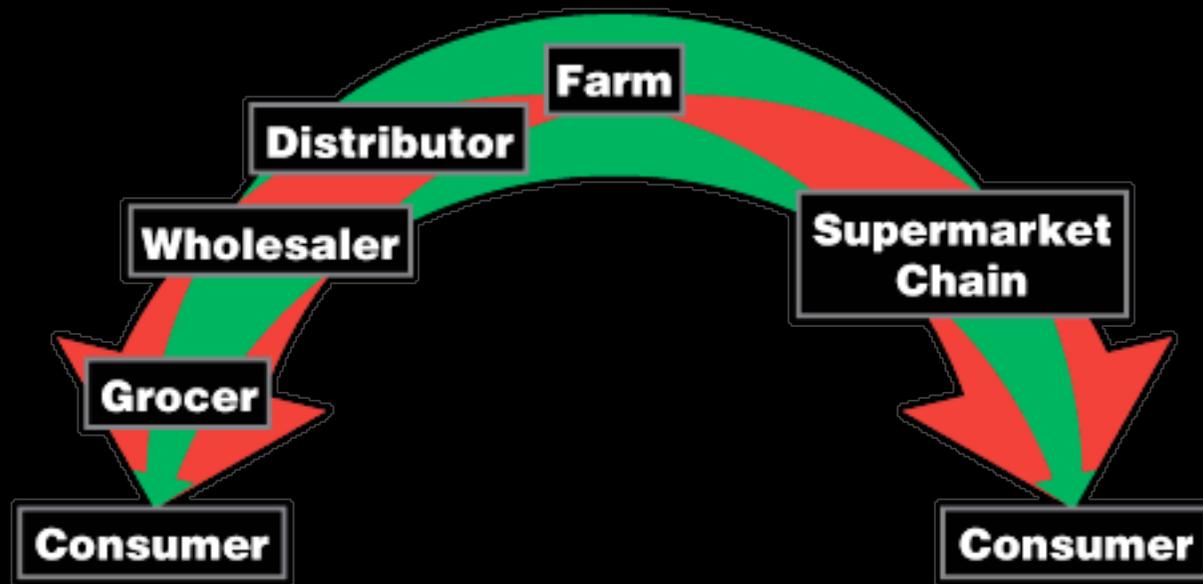
Cost increases with time & distance



The **cost** of a piece of fruit increases, the further it gets from the farm which produced it.

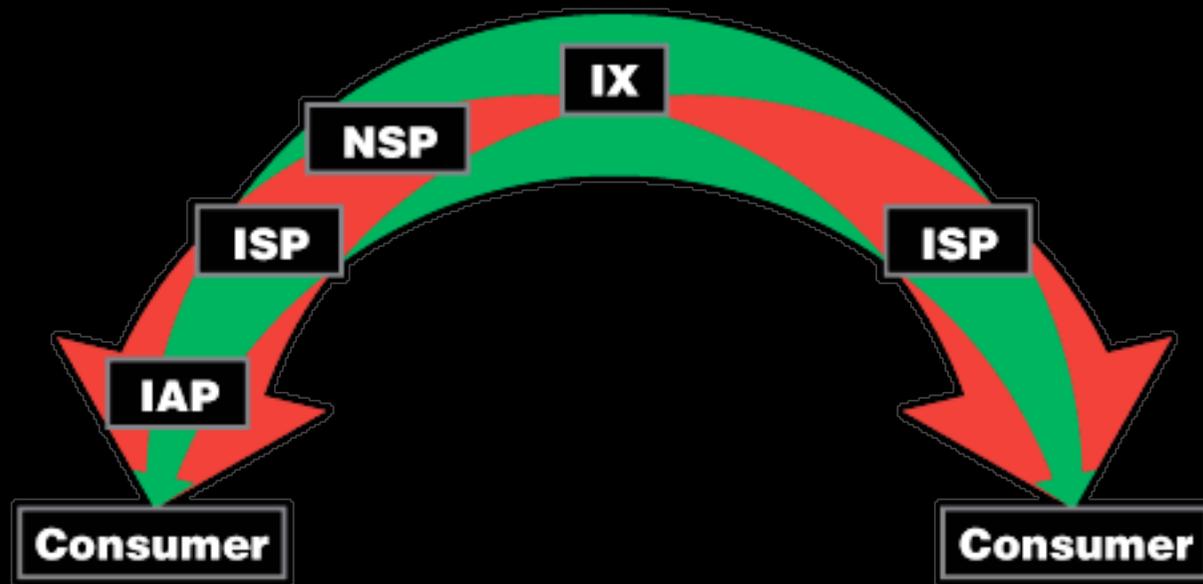
Salaries and hourly labor, warehouse leasing, petrol, lorry amortization, loss and spoilage, insurance, and other factors contribute additively.





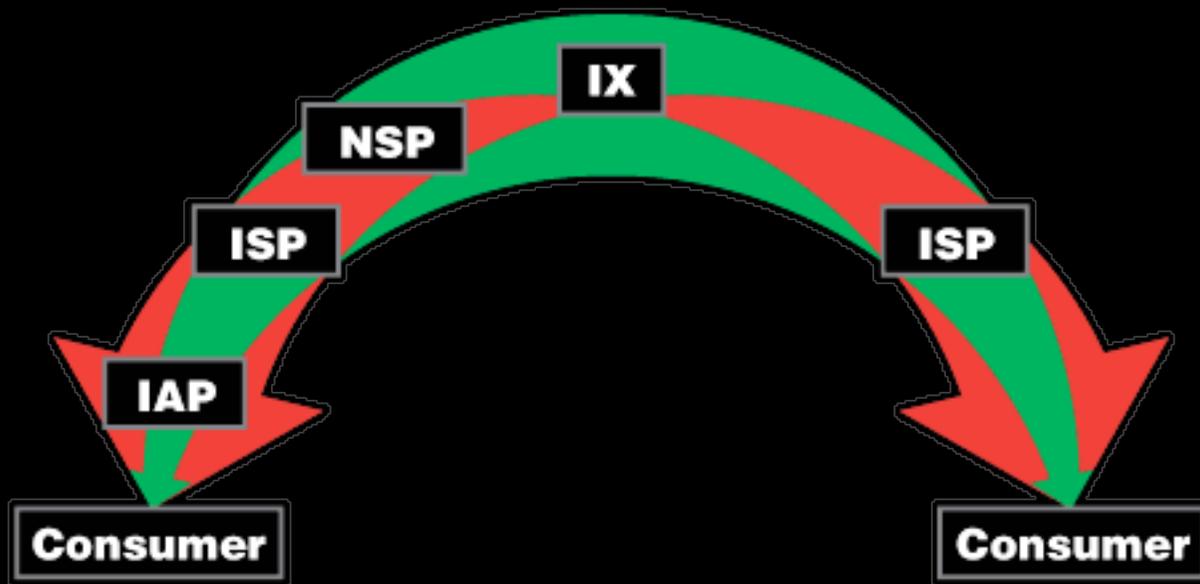
In a competitive environment, retail price is limited by competition, so time and distance influence the price more than the number of middlemen.

The problem is the same:

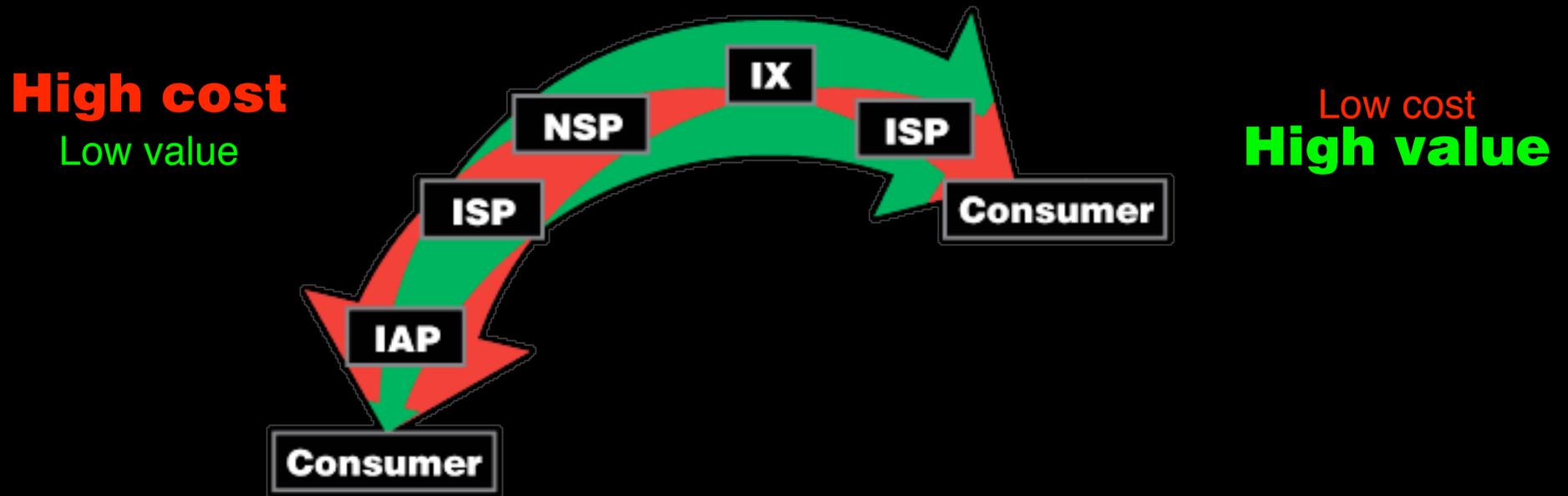


ISPs form a delivery chain, bringing perishable bits to the consumers who purchase them.

So how do we improve things?



Bring the customer nearer an IX...



...or bring an IX nearer the customer.

More Than 400 IXPs Today

- ~ 150 in North America
- ~ 150 in Europe
- ~ 80 in Asia-Pacific
- 11 in Africa
- 10 in Latin America
- ~ 2 in the Middle-East

Africa



Two Large IXes



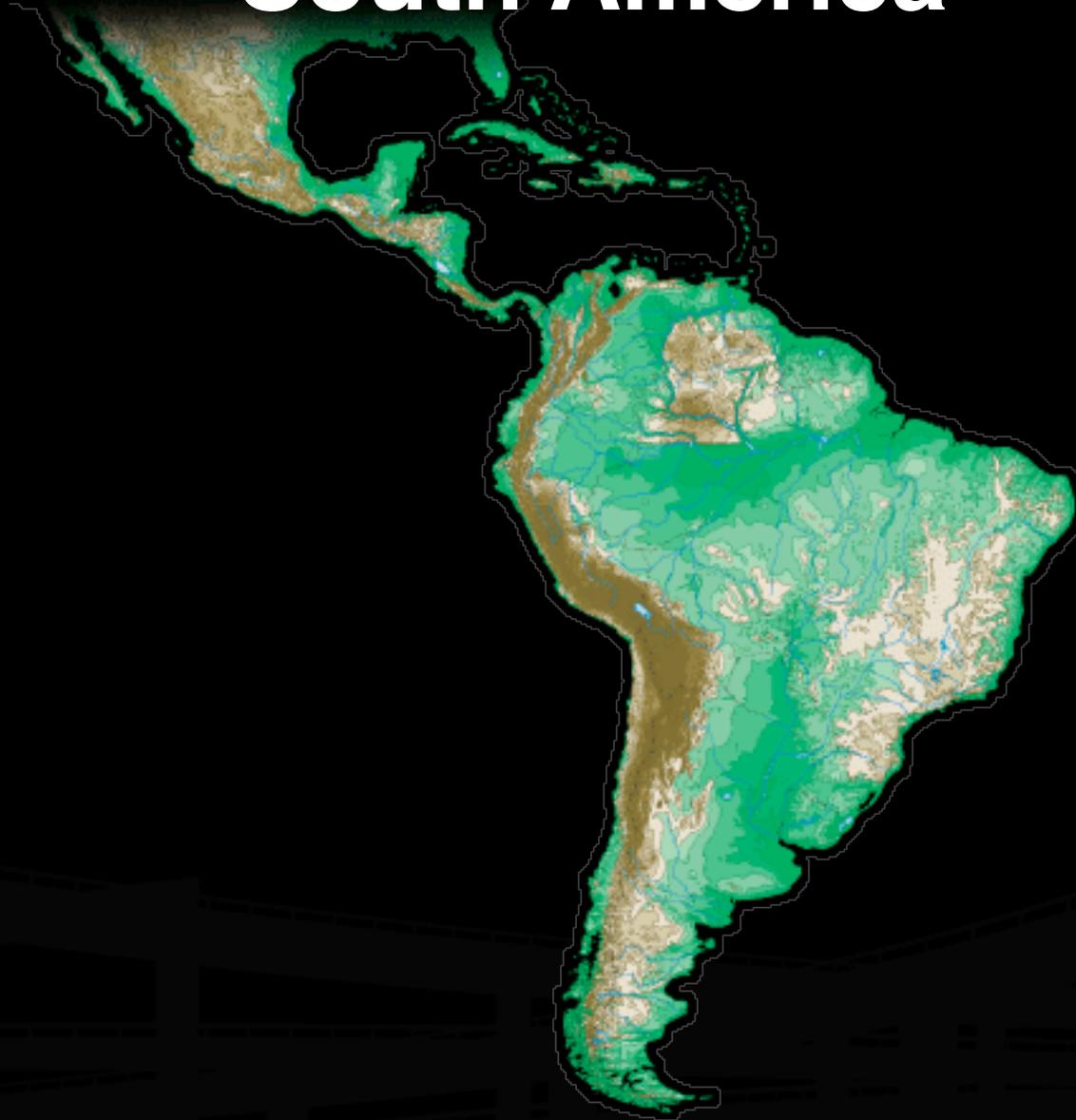
Eight Smaller IXes



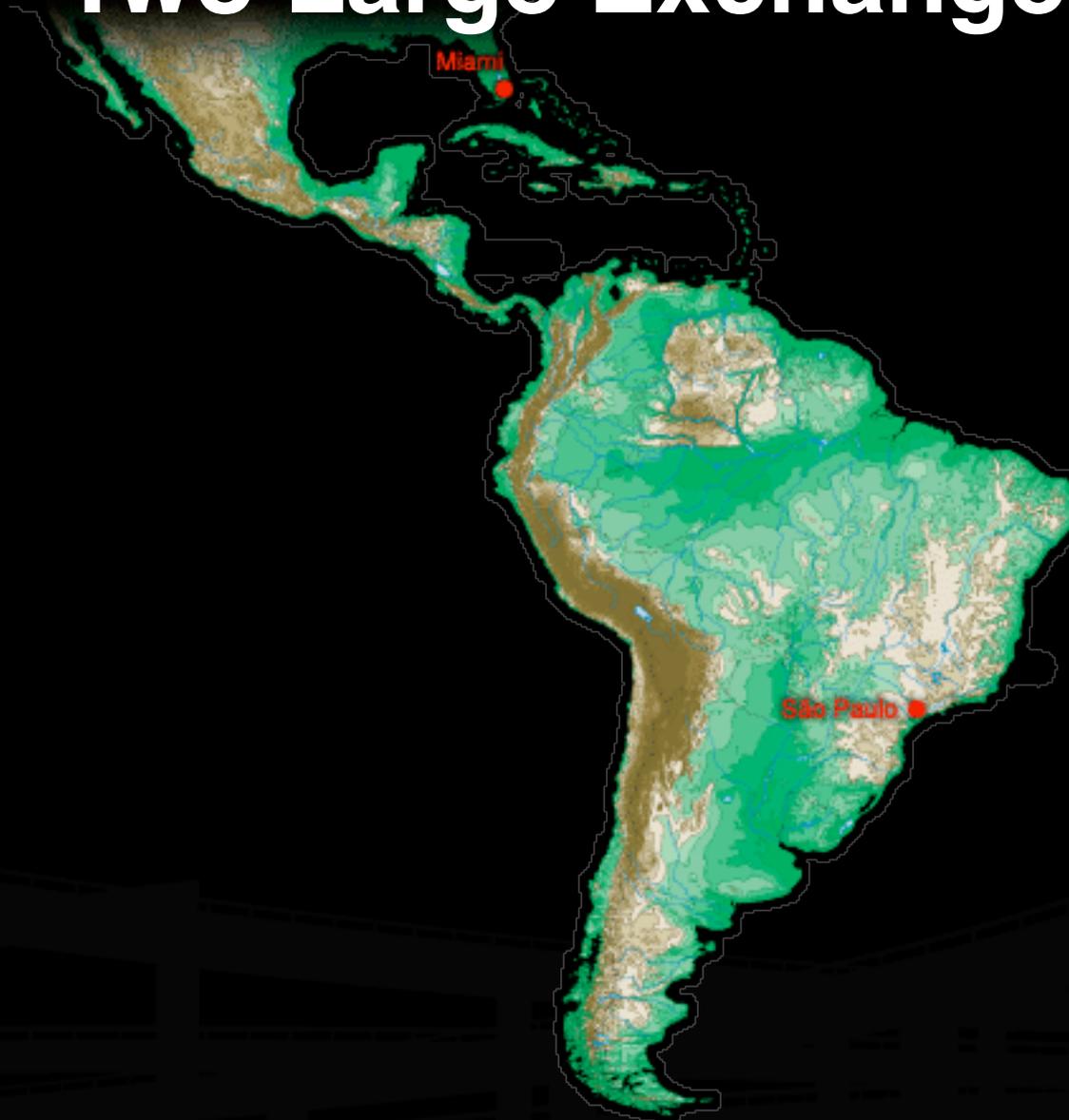
All 13 African IXes

	Established	Participants	Traffic Volume
Johannesburg JINX	December 1996	15	45 mbps
Cairo CAIX	December 2002	3	12 mbps
Maputo MozIX	July 2002	7	4 mbps
Nairobi KIXP	February 2002	11	3 mbps
Dar es Salaam TIX	January 2004	10	3 mbps
Kinshasa PdX	November 2002	4	1 mbps
Kigali	July 2004	6	400 kbps
Ibadan	March 2003	2	200 kbps
Mbabane SZIXP	June 2004	3	128 kbps
Zimbabwe ZINX	July 2001	5	
Mauritius MIXP	December 2005	7	
Accra GIXP	October 2005	4	
Kampala UIXP	July 2003	3	

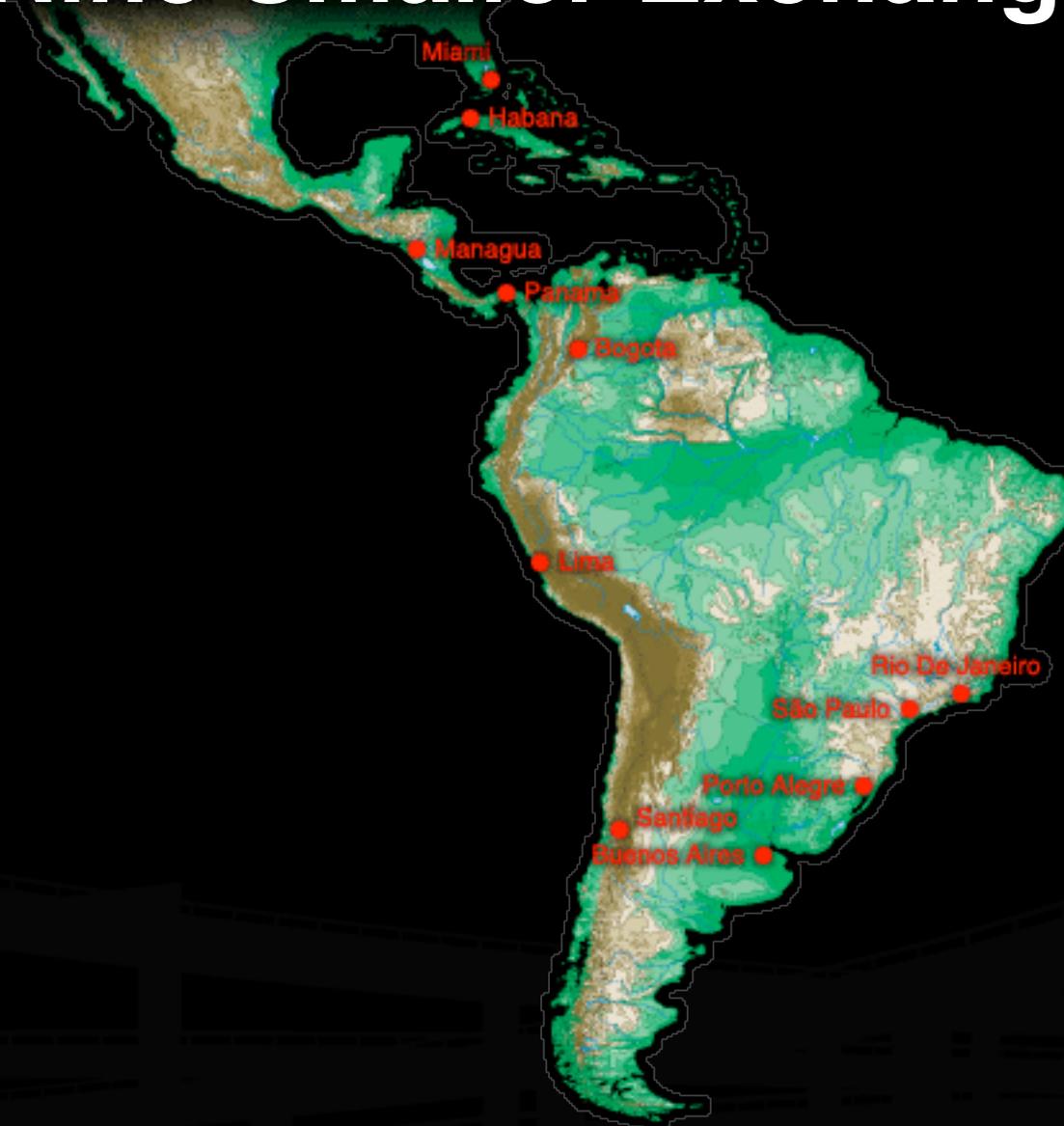
South America



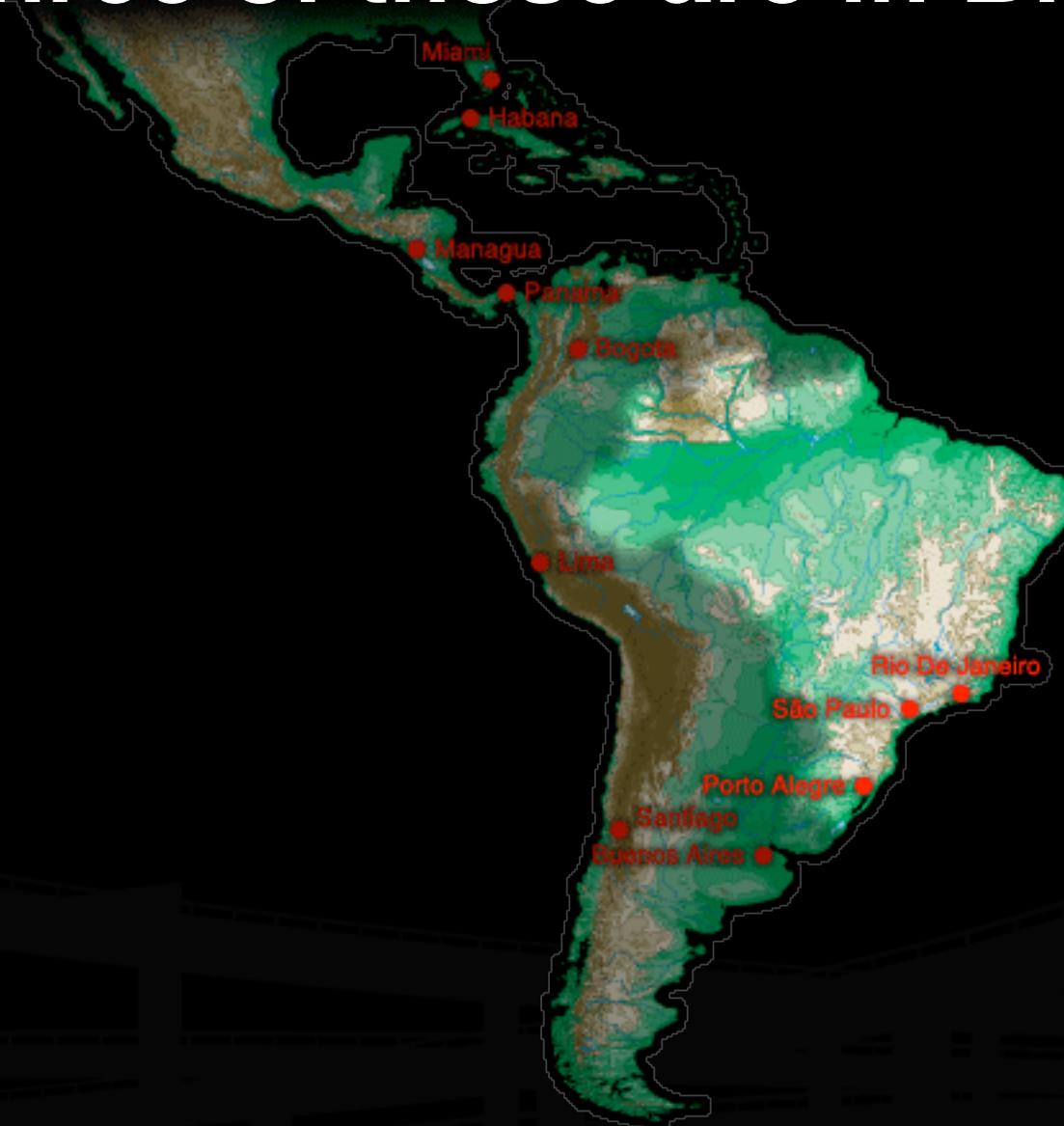
Two Large Exchanges



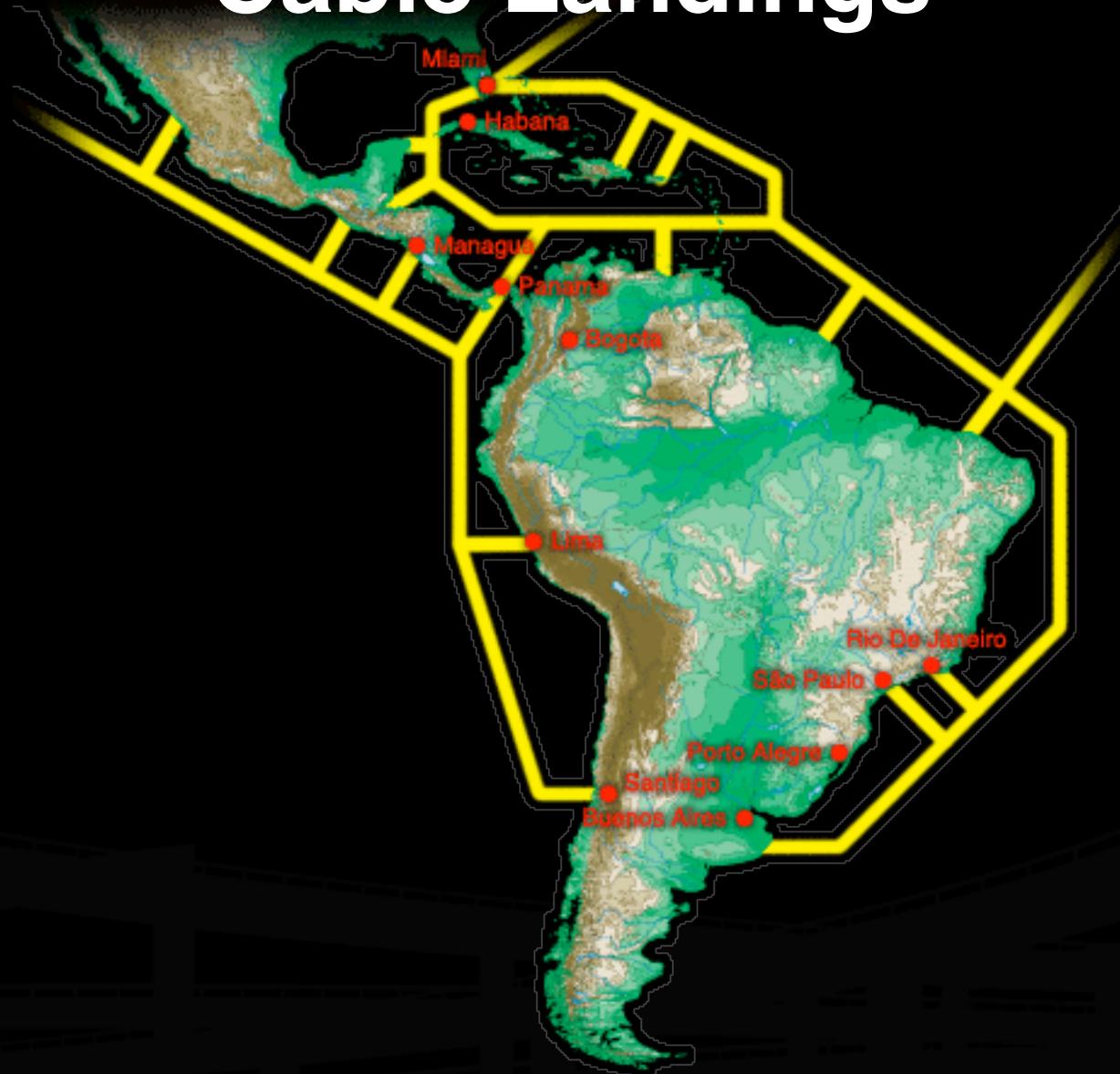
Nine Smaller Exchanges



Three of those are in Brazil



Cable Landings



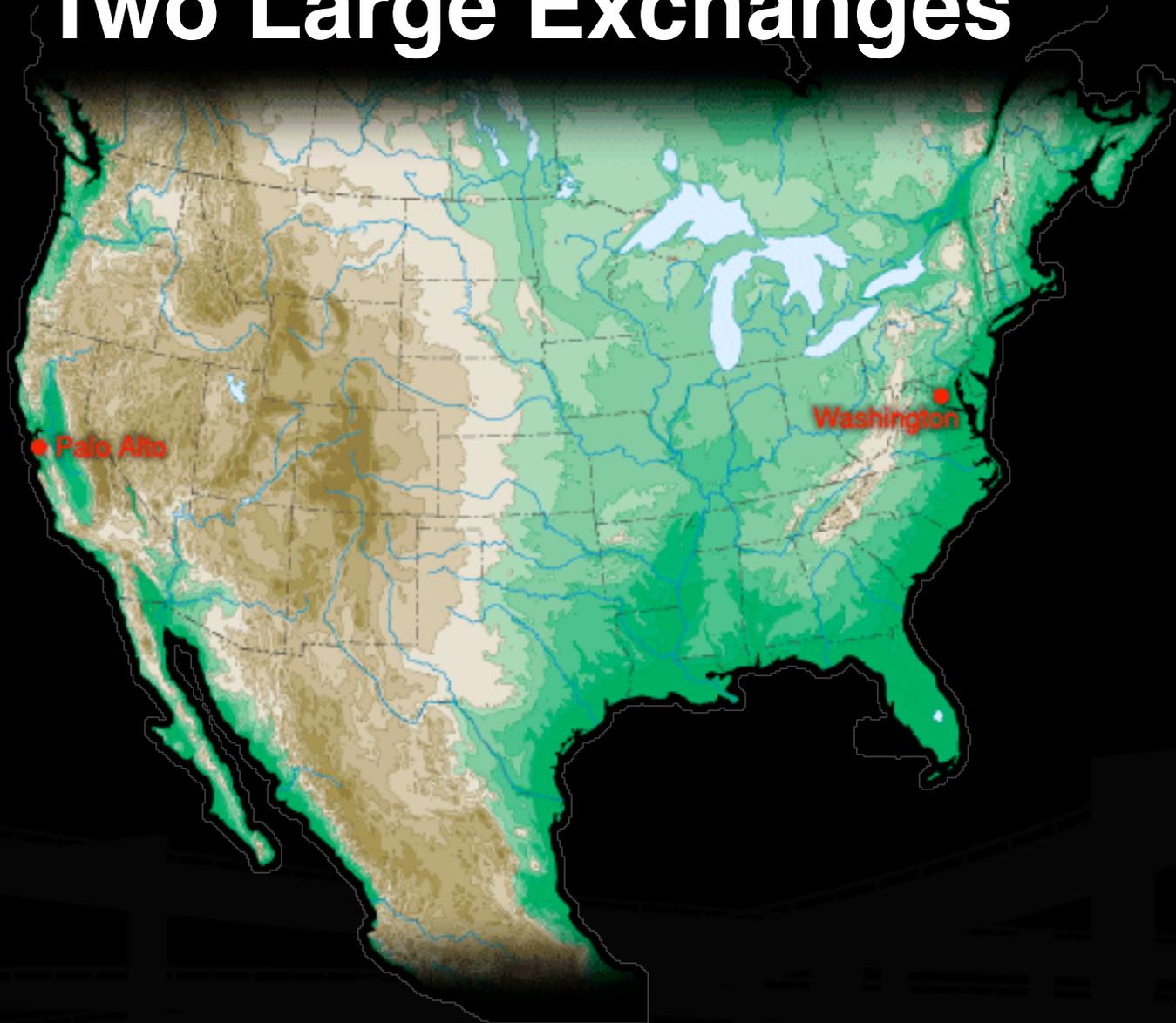
A Few of South America's 19 Exchanges

	Established	Participants	Traffic Volume
São Paulo	January 1998	45	1.3 gbps
Buenos Aires	April 1998	45	500 mbps
Porto Alegre	2000	15	160 mbps
Curitiba	January 2002	11	90 mbps
Asuncion	2000	14	40 mbps
Quito	January 2003	6	25 mbps
Guayaquil	2003	6	15 mbps
Managua	April 2004	10	

North America



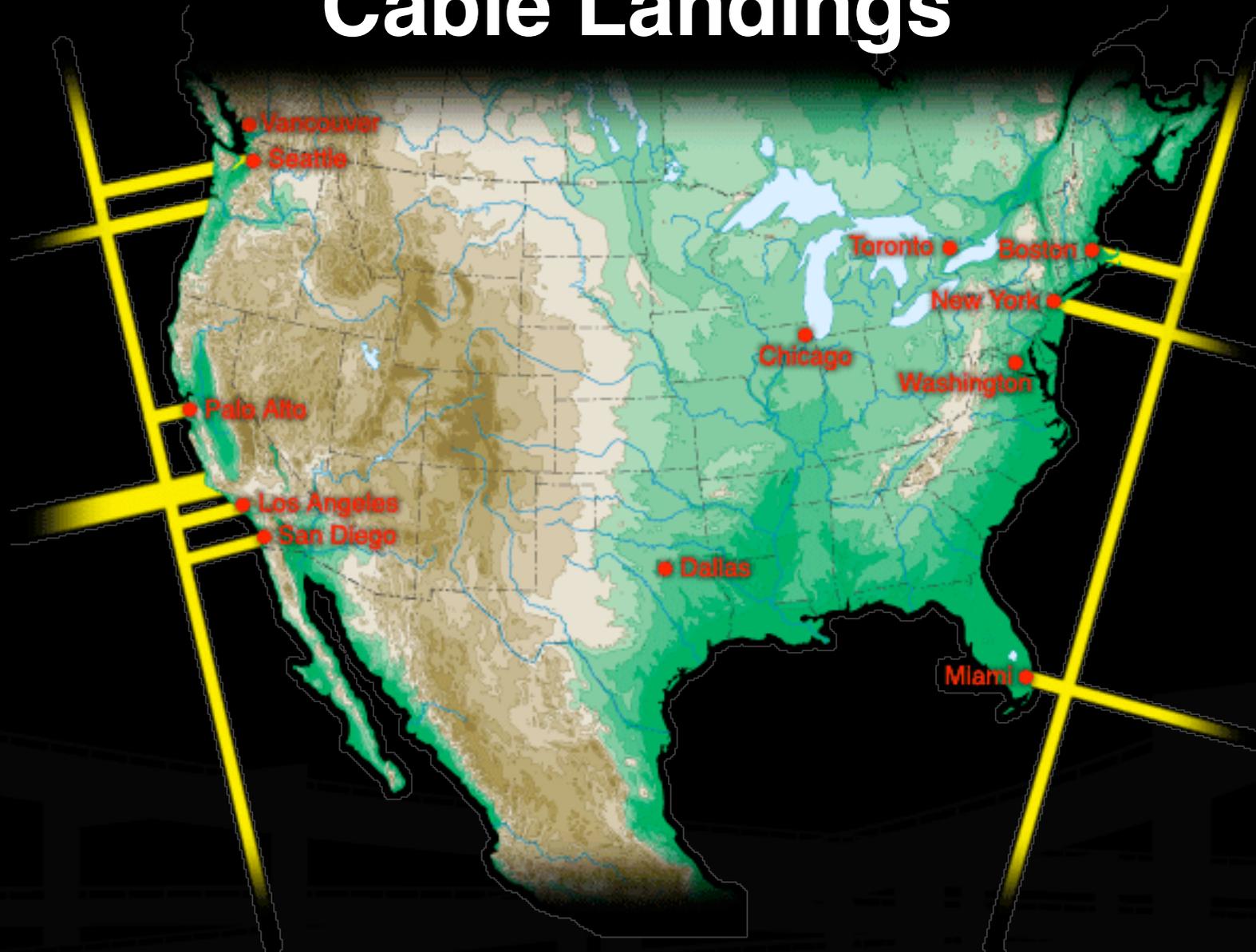
Two Large Exchanges



Many Smaller Exchanges



Cable Landings



A Few of North America's 110 IXes

	Established	Participants	Traffic Volume
Palo Alto PAIX	1994	180	
Ashburn Equinix	1999	72	
New York IIX	1998	80	
Seattle SIX	1996	90	6 gbps
Miami NOTA	2001	89	5 gbps
Los Angeles LAAP	1995	75	
Chicago Equinix	2001	36	
San Jose Equinix	2001	37	
Portland NWAX	2002	15	
San Jose MAE-West	1994	100	

Asia-Pacific



Three Large Exchanges



Many Medium-Sized Exchanges



Cable Landings



A Few Asian IXes

	Established	Participants	Traffic Volume
Seoul	1996	148	168 gbps
Tokyo	1996	252	125 gbps
Beijing	2000	8	50 gbps
Hong Kong	1995	69	13 gbps
Osaka	1998	30	5 gbps
Jakarta	1997	99	4 gbps
Taipei	1998	77	2 gbps
Wellington	1996	123	
Auckland	1999	48	
Perth	1997	52	550 mbps
Singapore	2001	12	500 mbps

Europe



Two Large Exchanges



Many, Many Smaller Exchanges



Cable Landings



A Few of Europe's 70 IXes

	Established	Participants	Traffic Volume
Amsterdam AMS-IX	1997	212	53 gbps
London LINX	1996	169	49 gbps
Frankfurt DE-CIX	1995	140	28 gbps
Stockholm NetNod	1997	35	13 gbps
Milan MIX	2000	56	8 gbps
Prague NIX	1996	50	6 gbps
London XchangePoint	2001	166	6 gbps
Vienna VIX	1996	82	5 gbps
Gothenburg NetNod	2002	11	2 gbps
Rome NaMeX	1995	15	2 gbps

How are Exchanges Run?

Business models

Commercial (loss-making)

Non-commercial (savings taken by participants)

Governance models

Autocratic

Democratic

Entity type

Corporation

Unincorporated project

How is Stability Ensured?

Technical stability

- Keep it simple
- Minimize changes
- Don't fix what's not broken

Organizational stability

- Minimize shared costs and risks
- Minimize possibility of monopolization
- Minimize possibility of coercion



**FRNOG 2006:
INOC-DBA
Hotline Phone System**

May, 2006

Bill Woodcock

Packet Clearing House

What's it About?

INOC-DBA: Inter-Network Operations Center,
Dial-by-Autonomous System Number

Global Voice-over-IP hotline phone system,
directly interconnecting NOCs and SIRTs within
carriers, ISPs, exchange points, and vendors.

How does it work?

If you just dial an Autonomous System Number, it'll ring a predefined group of phones within that AS. (example: 42)

If you dial an ASN and an extension number, it'll ring the phones belonging to that person.
(example: 42*WEW)

Also, well-known extensions for NOC, abuse, routing, SIRT, et cetera.

How does it work?

SIP is similar to Dynamic DNS.

Pick up an address via DHCP or statically

Download config from preconfigured server

Register current IP address with a SIP Registry

Registry transfers IP address to SIP Proxies

When someone calls your phone, they do a dialed-number-to-IP-address lookup against the proxy

Then their phone contacts yours directly.

Any Problems So Far?

CPE network environment:

- NAT and firewall traversal

- Unusual DHCP server options

Nothing a little static configuration can't overcome.

Unexpected Benefits

QoS is completely unnecessary.

Sound quality far exceeds that of the PSTN, even under the worst conditions.

Latency seems less annoying when it's not accompanied by degraded sound.

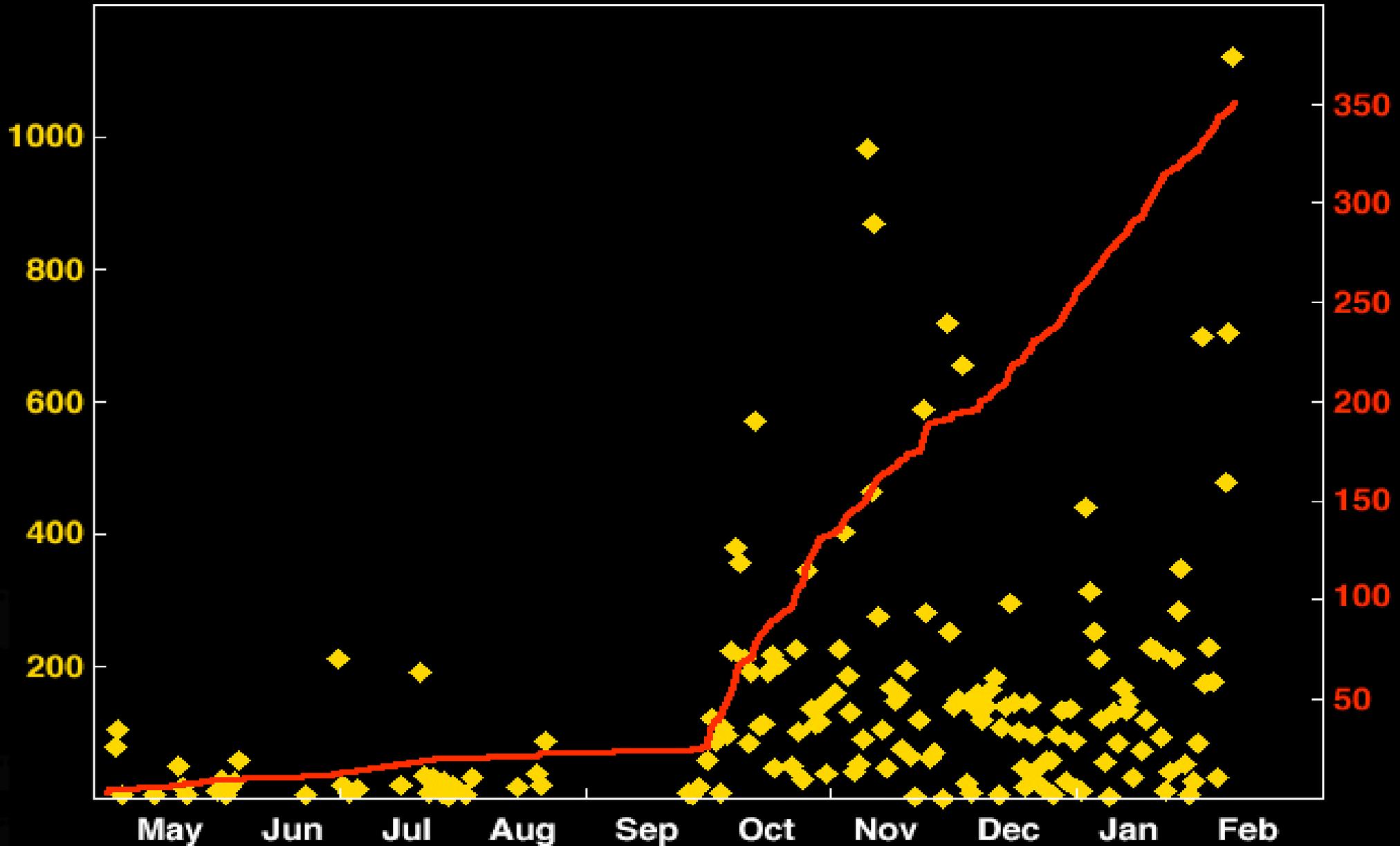
Is it Difficult to Set Up?

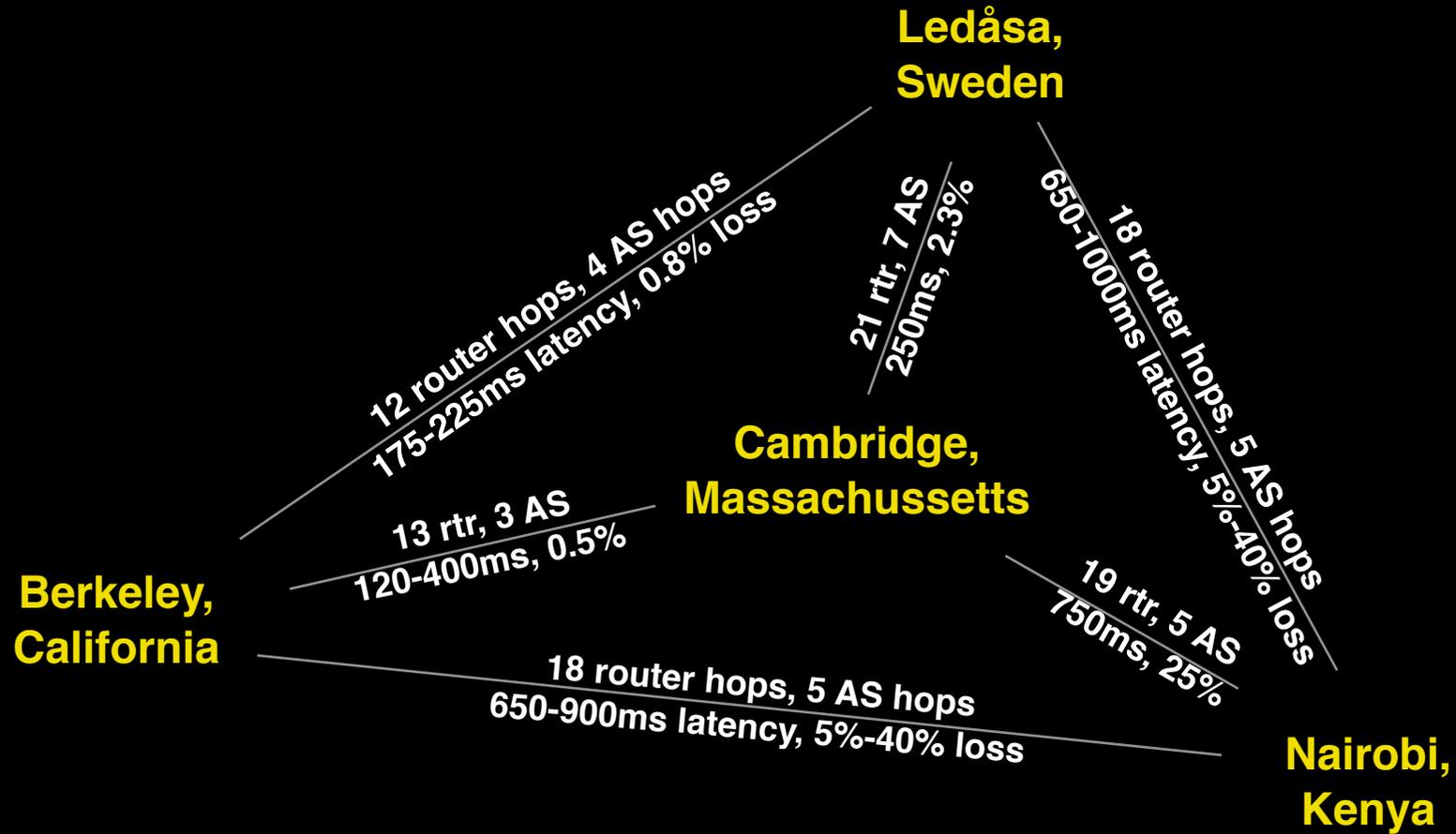
Not really...

Is it Difficult to Set Up?



Phone Deployment & Use





How to Participate

With your own phones:

We need your MAC address, contact info, ASNs, and extension number.

With phones from us:

We need your contact and shipping address, ASNs, and extension number.

More Information

General information:

<http://www.pch.net/inoc-dba/>

Mailing-list archive:

<http://www.pch.net/resources/discussion/inoc-dba/archive/>

Who's participating:

<http://www.pch.net/inoc-dba/directory/>

Exchanges

LINX	SD-NAP
PAIX	LAIX
Equinix	NSP-IXP2
AMS-IX	NOTA
MAEs	OIX

Carriers

UUnet	AT&T
Sprint	SBC
C&W	AOL/T-W
Genuity	RCN
Verio/NTT	TDS

Associations

ARIN
APNIC
RIPE/NCC
ICANN
ISC