Agenda for the Day

Morning: Overview of Internet economic building blocks

Afternoon: How to translate Internet growth into overall economic growth, follow-up on issues of interest, Q&A

Packet Clearing House

TunIXP Workshop on IXPs

April 29-30, 2013

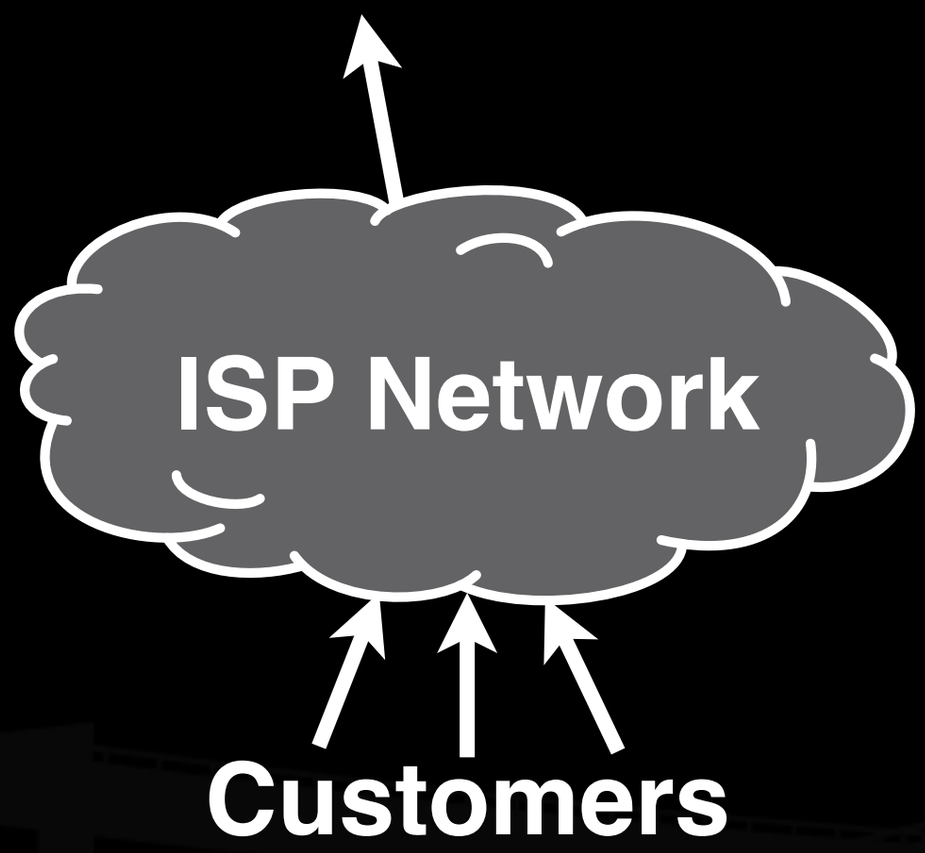
Tunis

Bill Woodcock

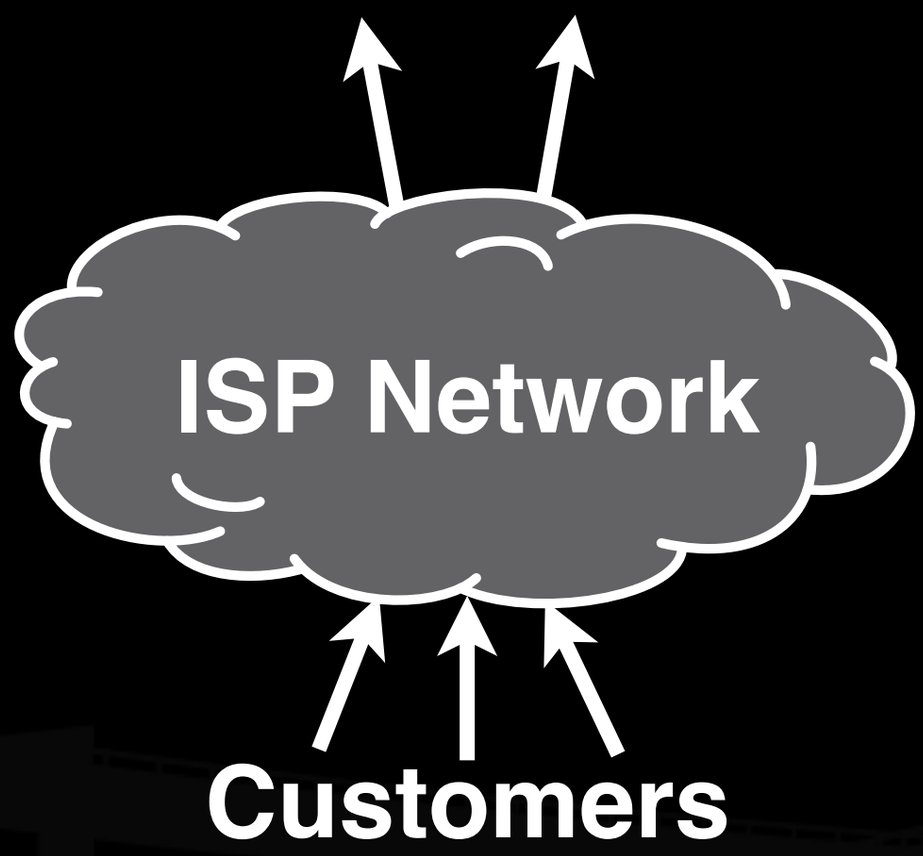
Executive Director

Packet Clearing House

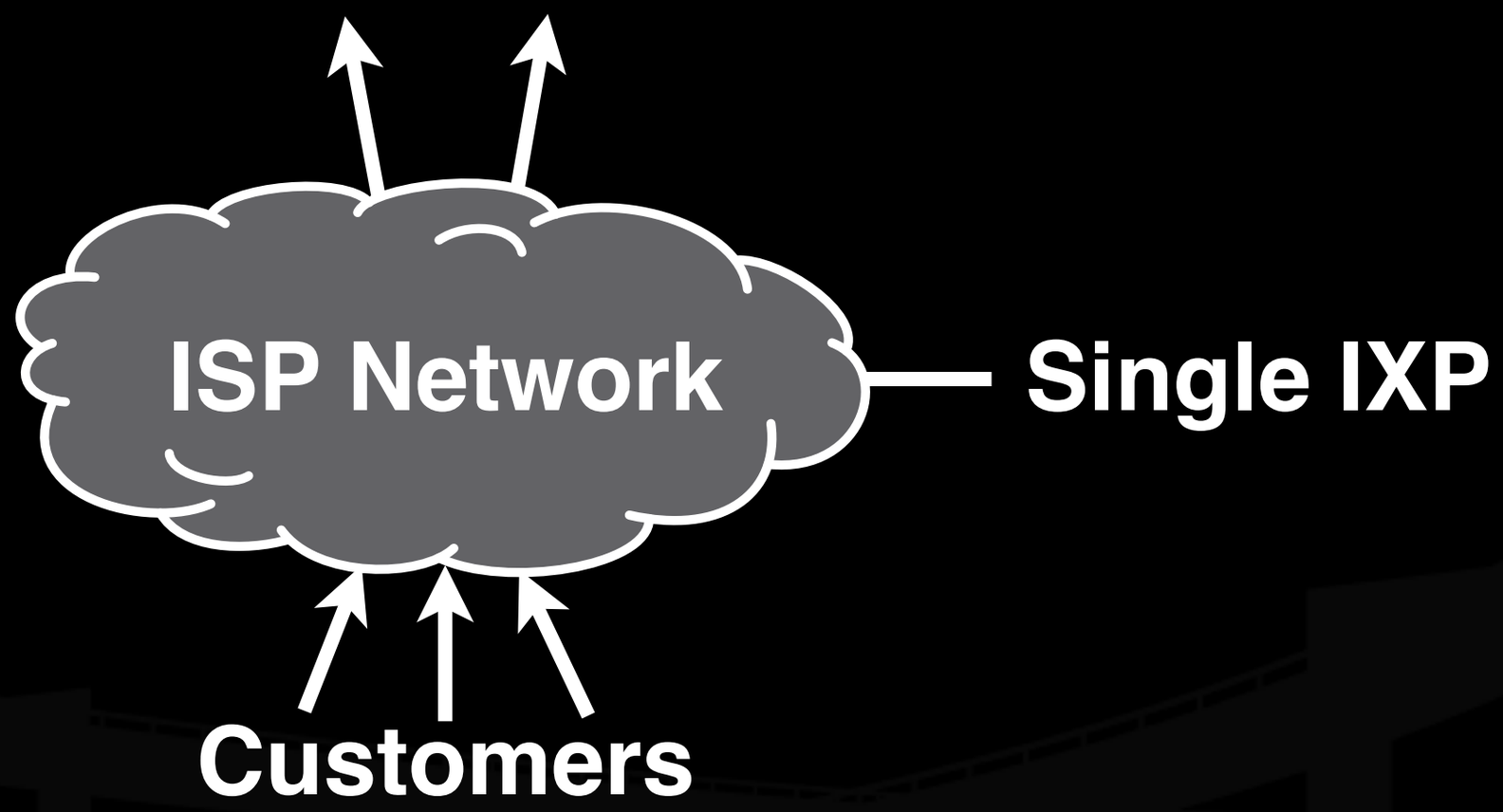
ISP Lifecycle: Simple Aggregator



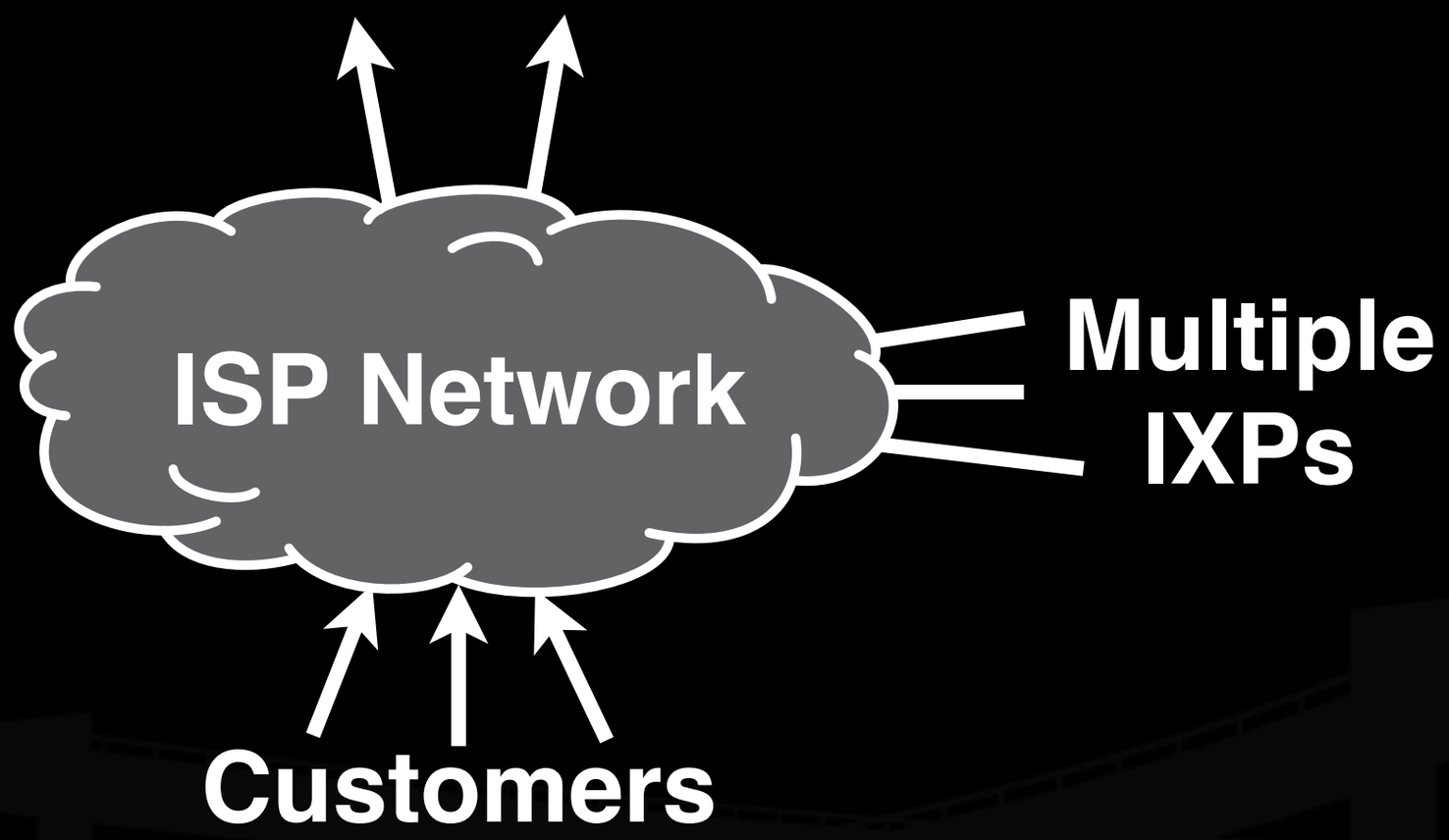
ISP Lifecycle: Redundancy and LCR



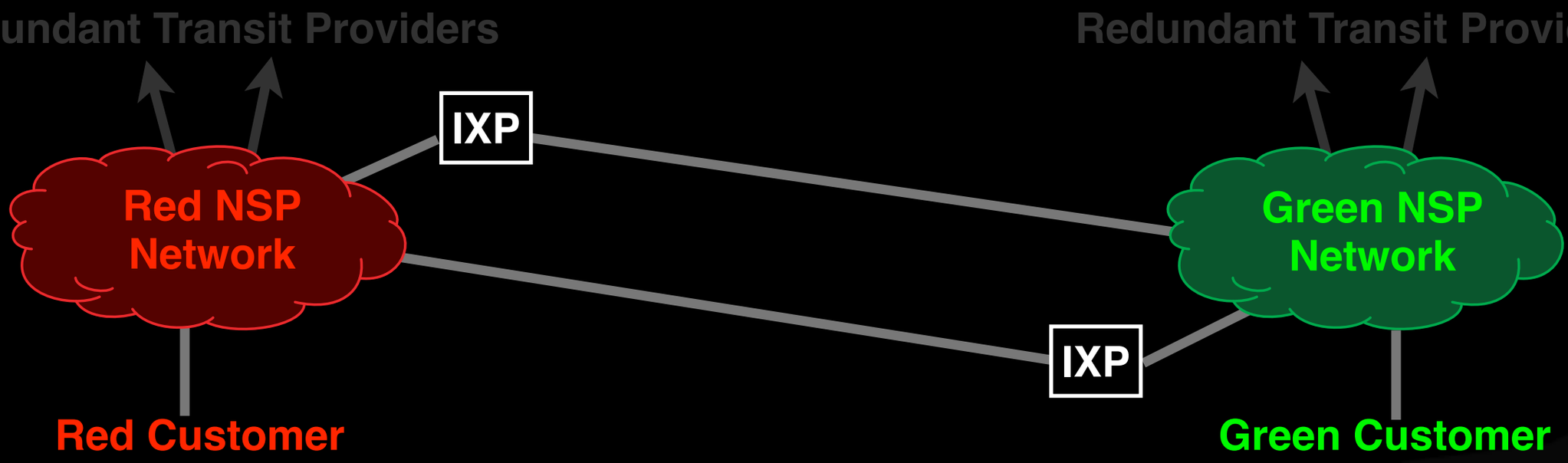
ISP Lifecycle: Local Peer



ISP Lifecycle: Backbone Network

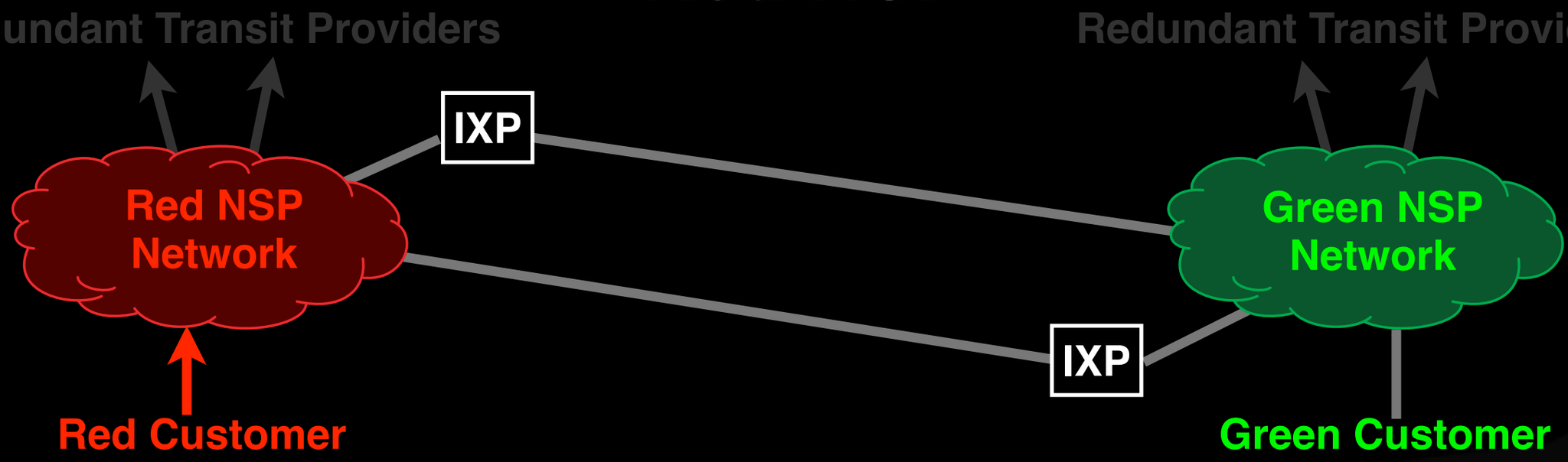


Hot Potato Routing



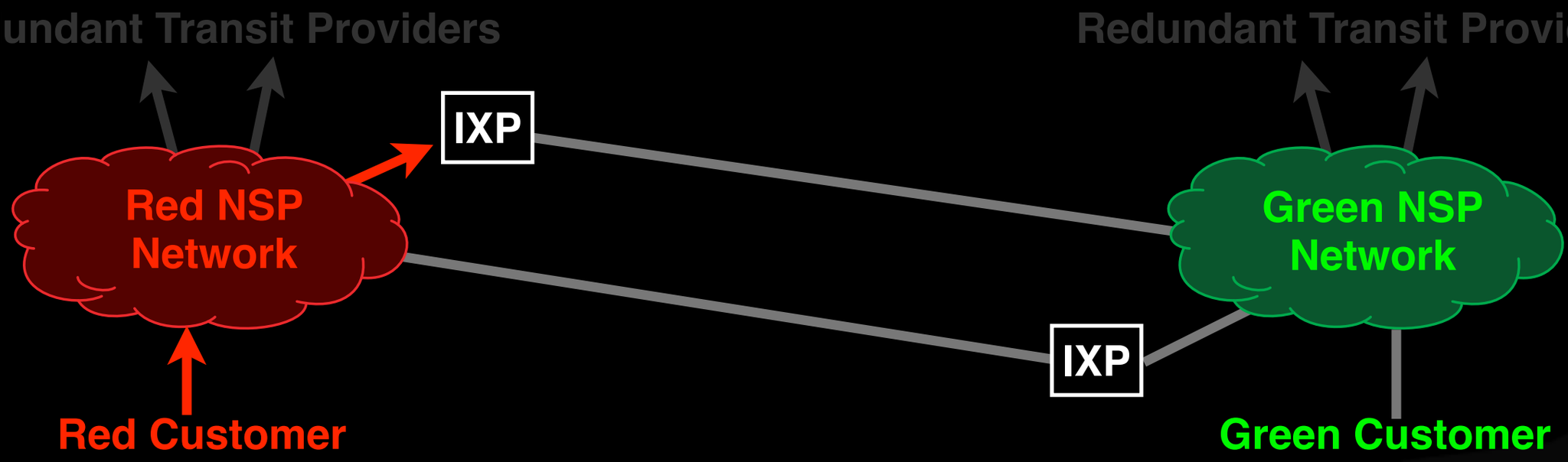
Hot Potato Routing

Red Customer sends to Green Customer via Red NSP



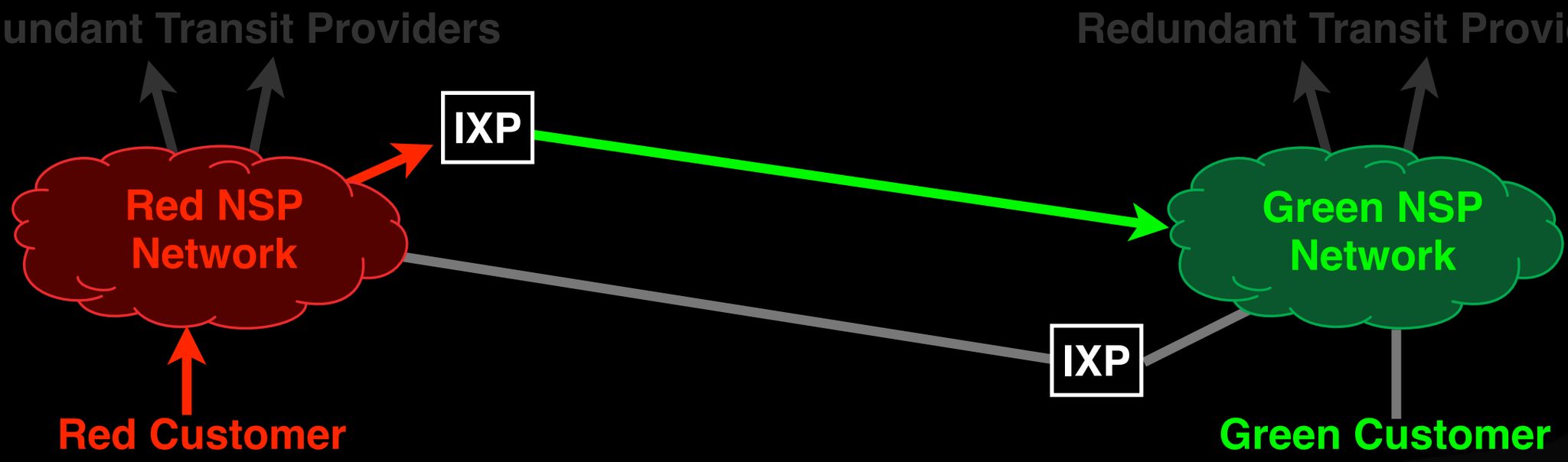
Hot Potato Routing

Red NSP delivers at *nearest* IXP



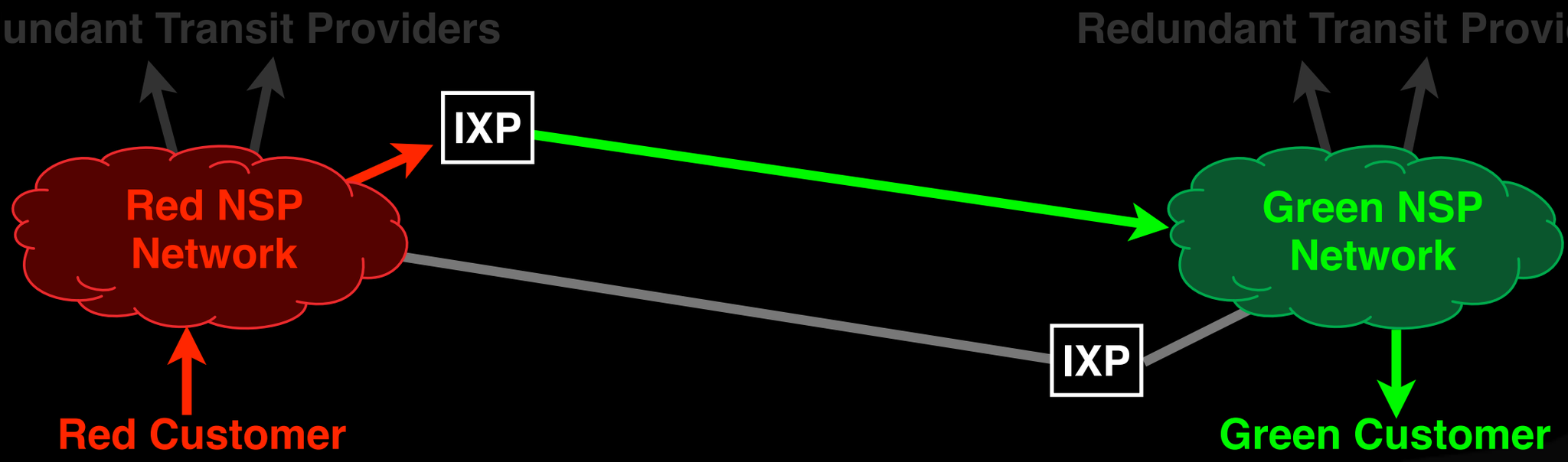
Hot Potato Routing

Green NSP backhauls from distant IXP



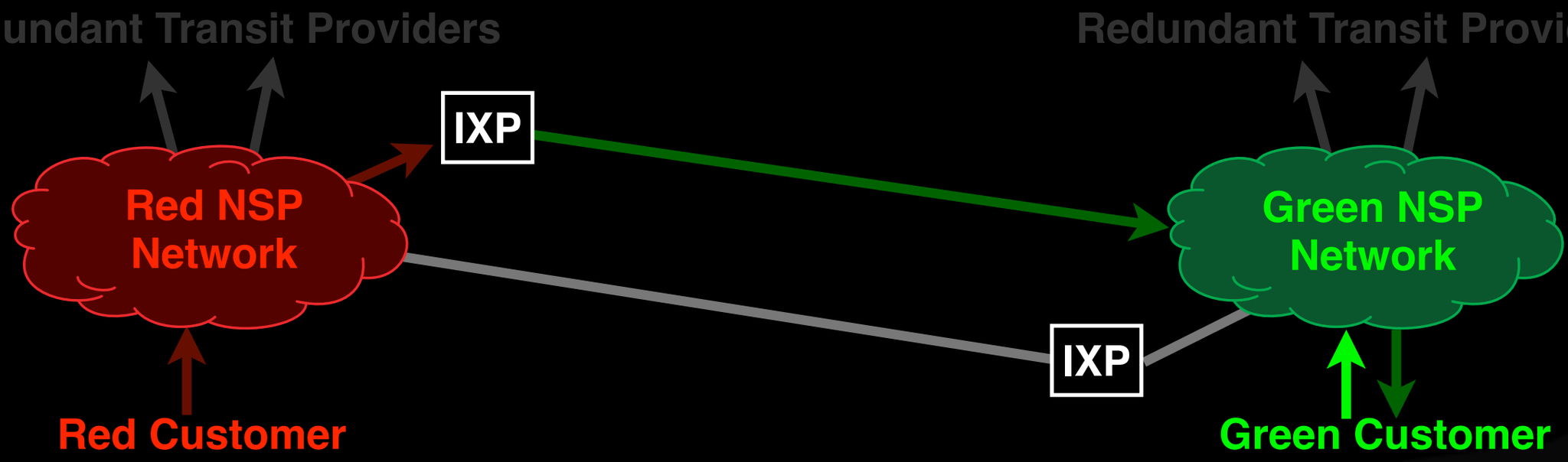
Hot Potato Routing

Green ISP delivers to Green Customer



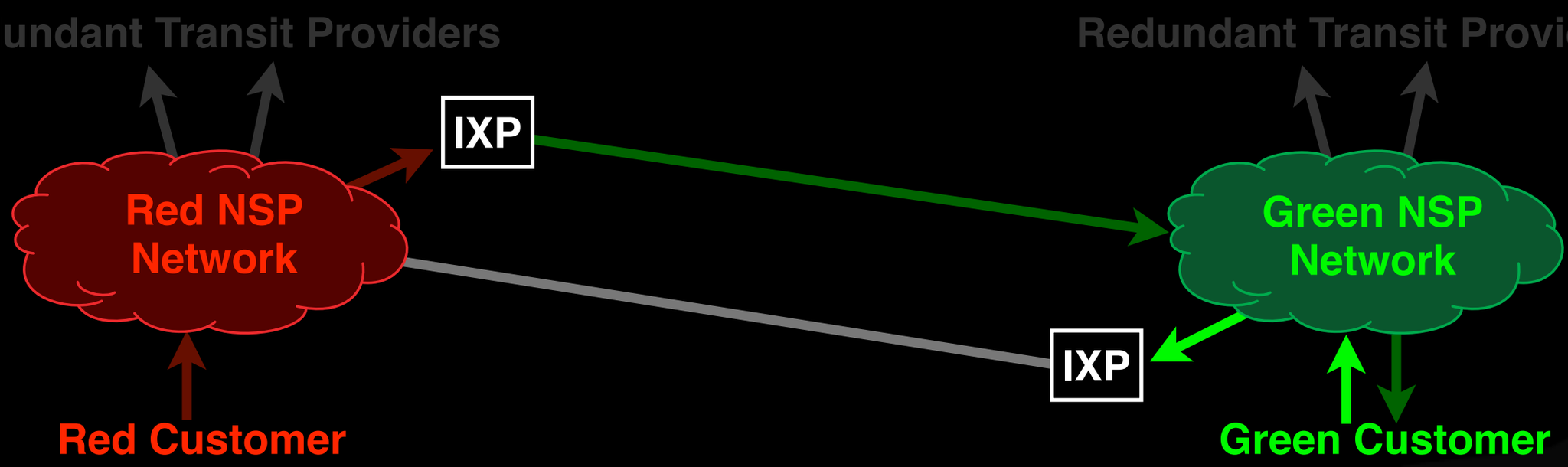
Hot Potato Routing

Green Customer replies via Green NSP



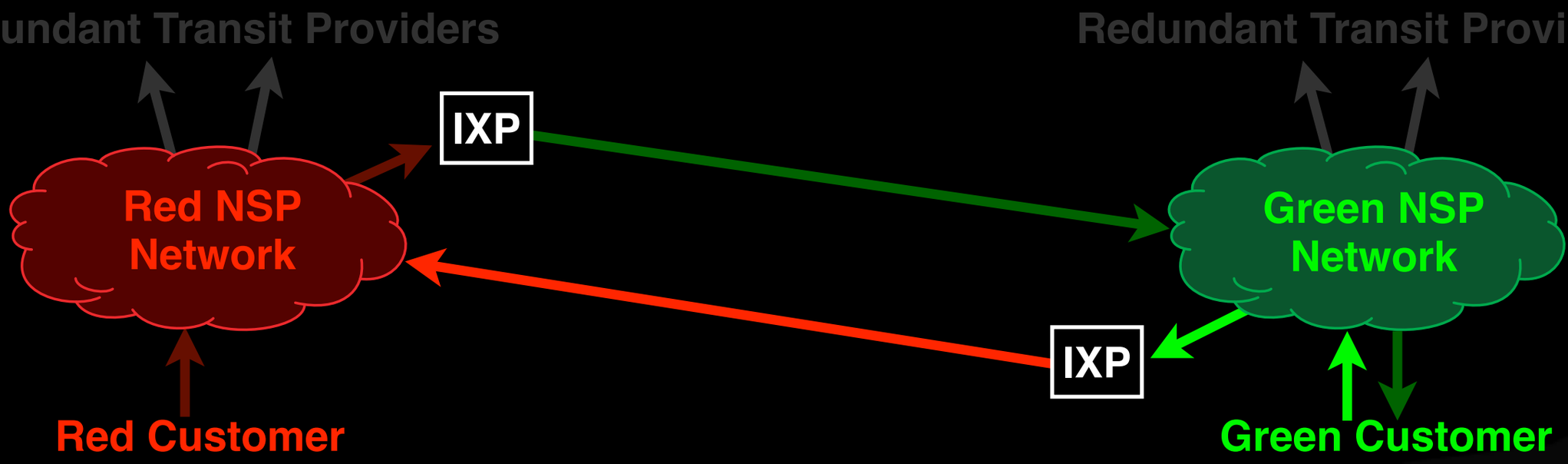
Hot Potato Routing

Green NSP delivers at nearest IXP



Hot Potato Routing

Red NSP backhauls from distant IXP



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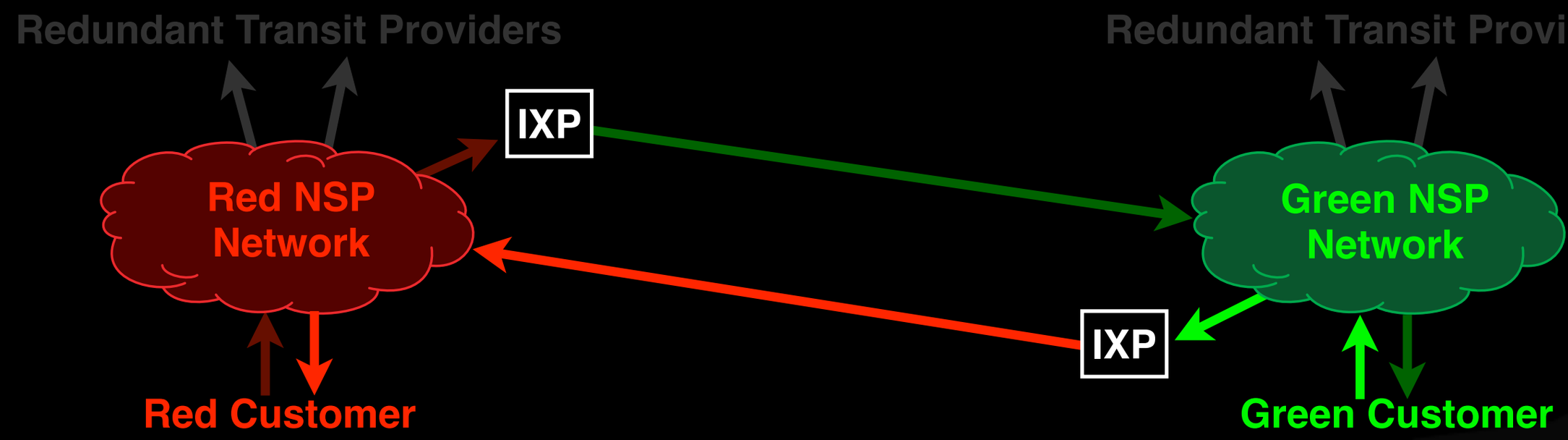
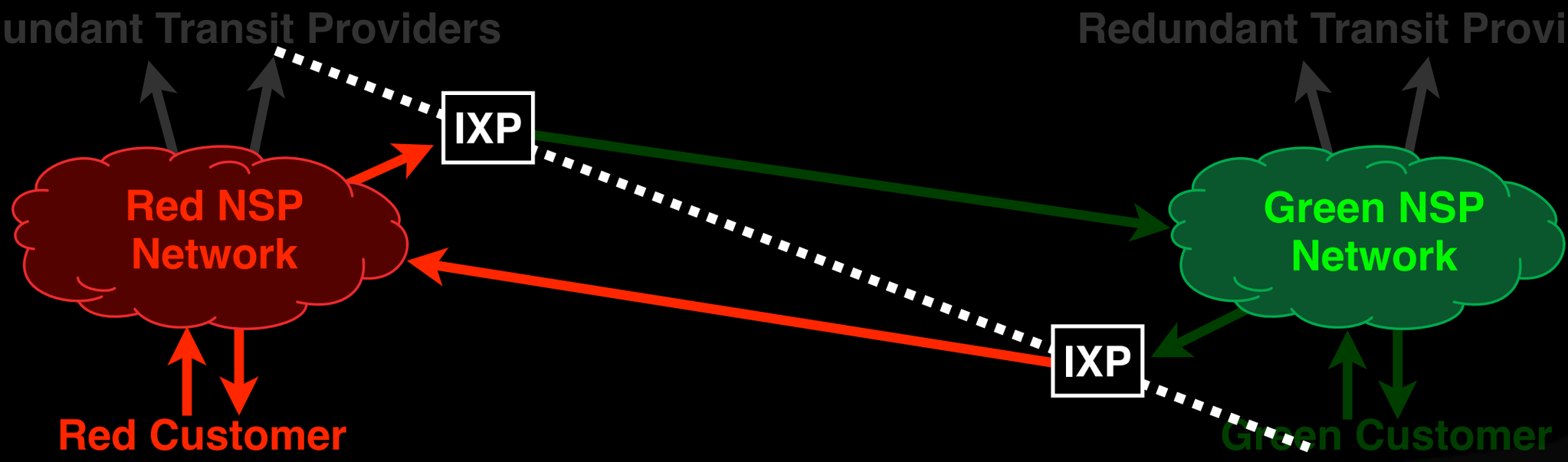
Hot Potato Routing

Red NSP delivers to Red Customer



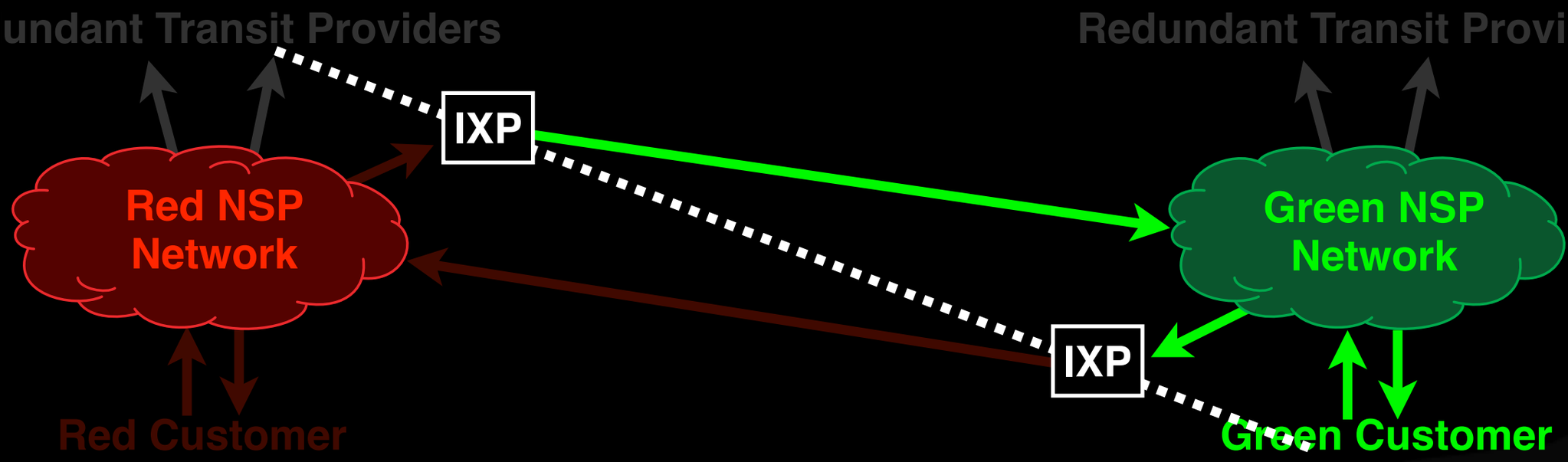
Hot Potato Routing

Red Network is responsible for its own costs



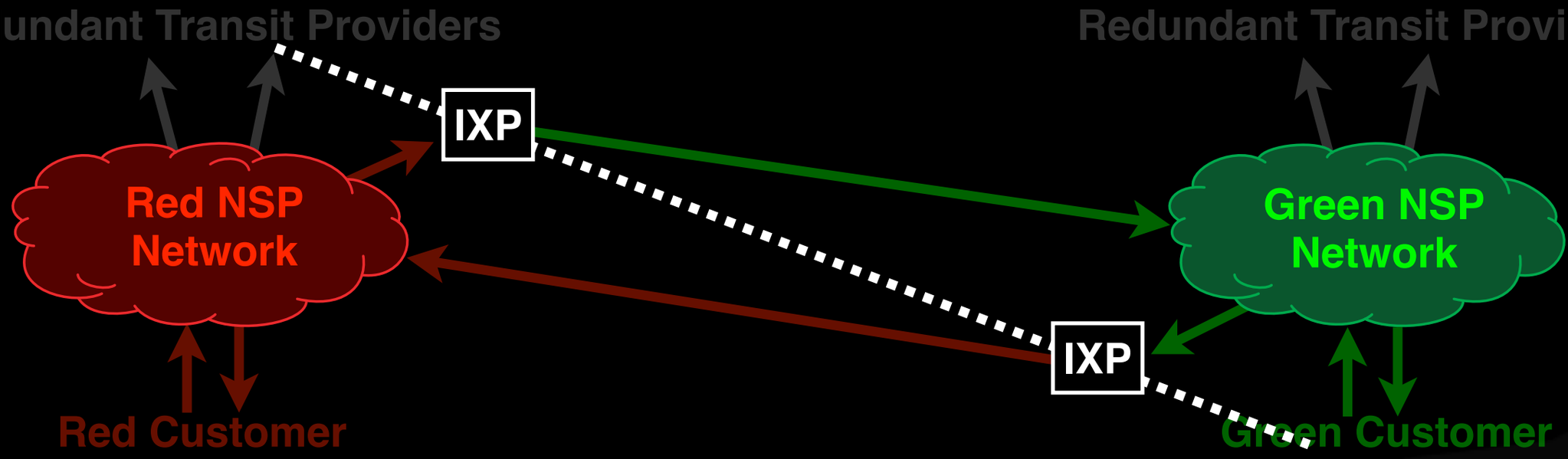
Hot Potato Routing

Green Network is responsible for its own costs



Hot Potato Routing

Symmetry: Fair sharing of costs



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The efficiency of the Internet depends upon this principle:

For any two parties who wish to exchange traffic, there must be a pair of exchanges, one near each party.

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The Corollary:

Countries which haven't yet built Internet Exchange Points disadvantage themselves, and export capital to countries that already have.

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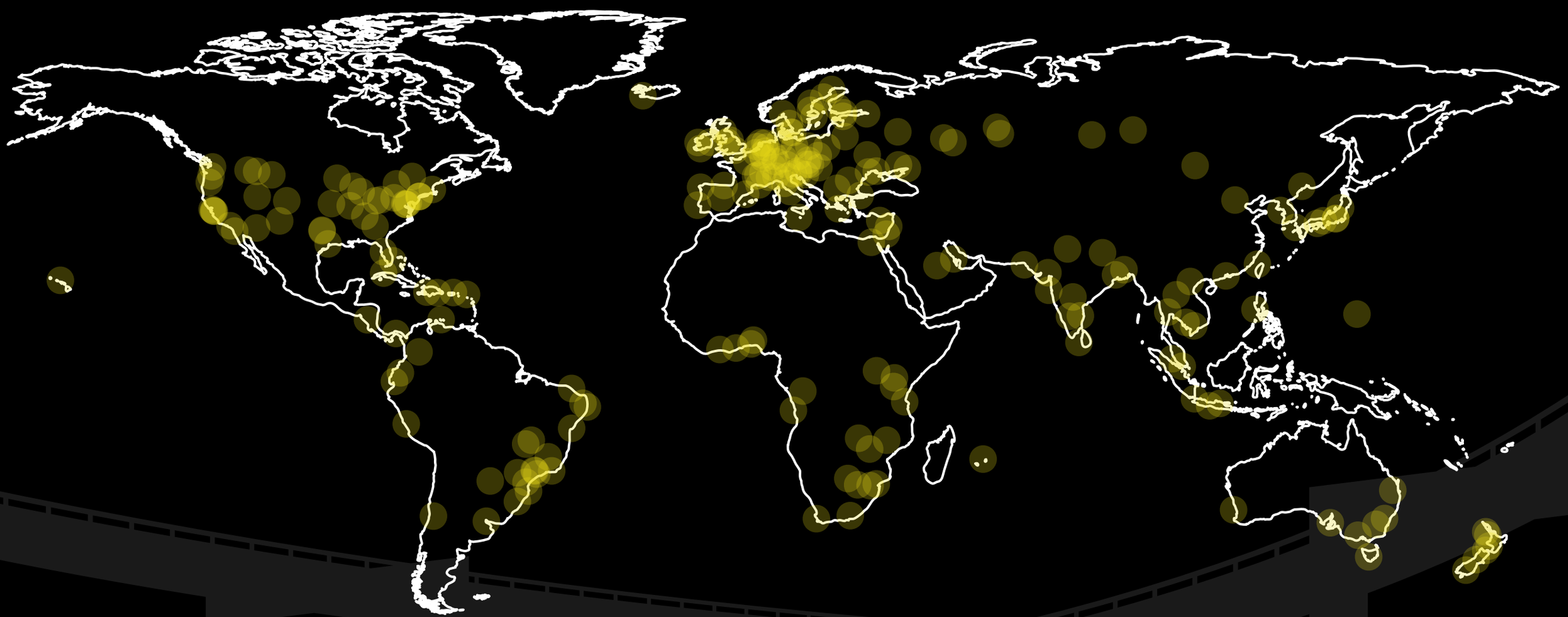
Distribution of IXPs

Half of all countries still have no IXP, while others have dozens.



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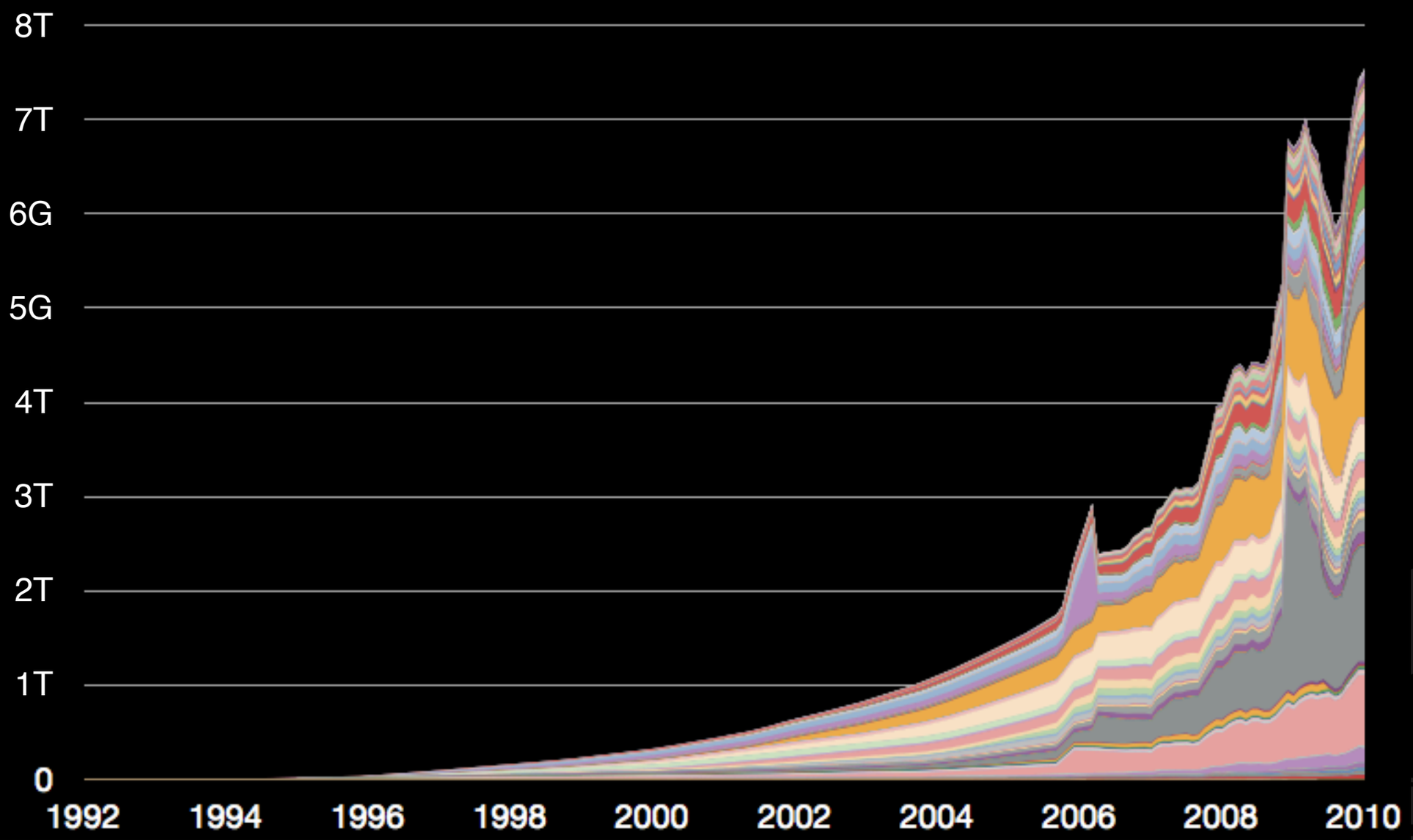
Global Bandwidth Production



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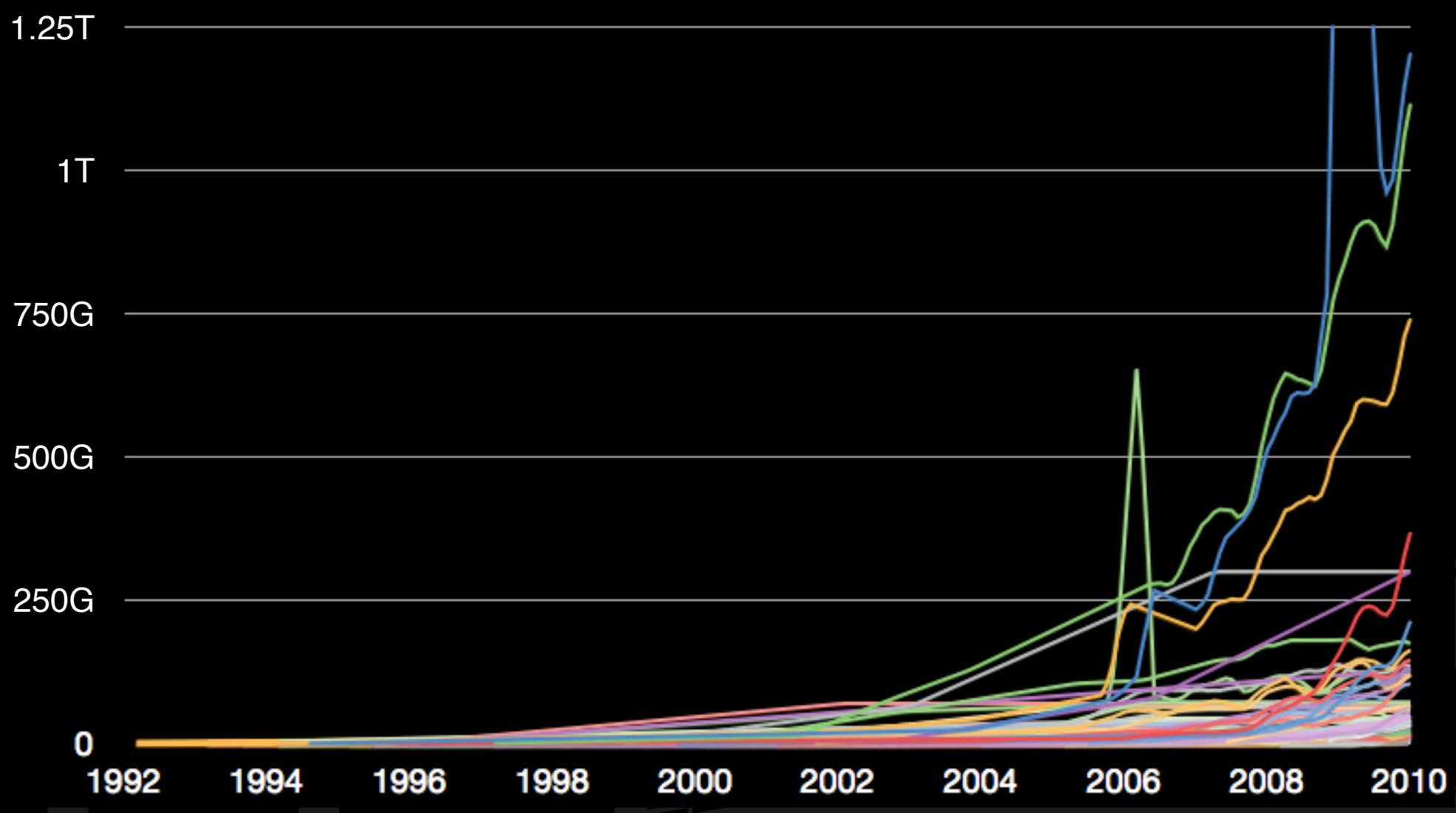
Bandwidth Production per IXP



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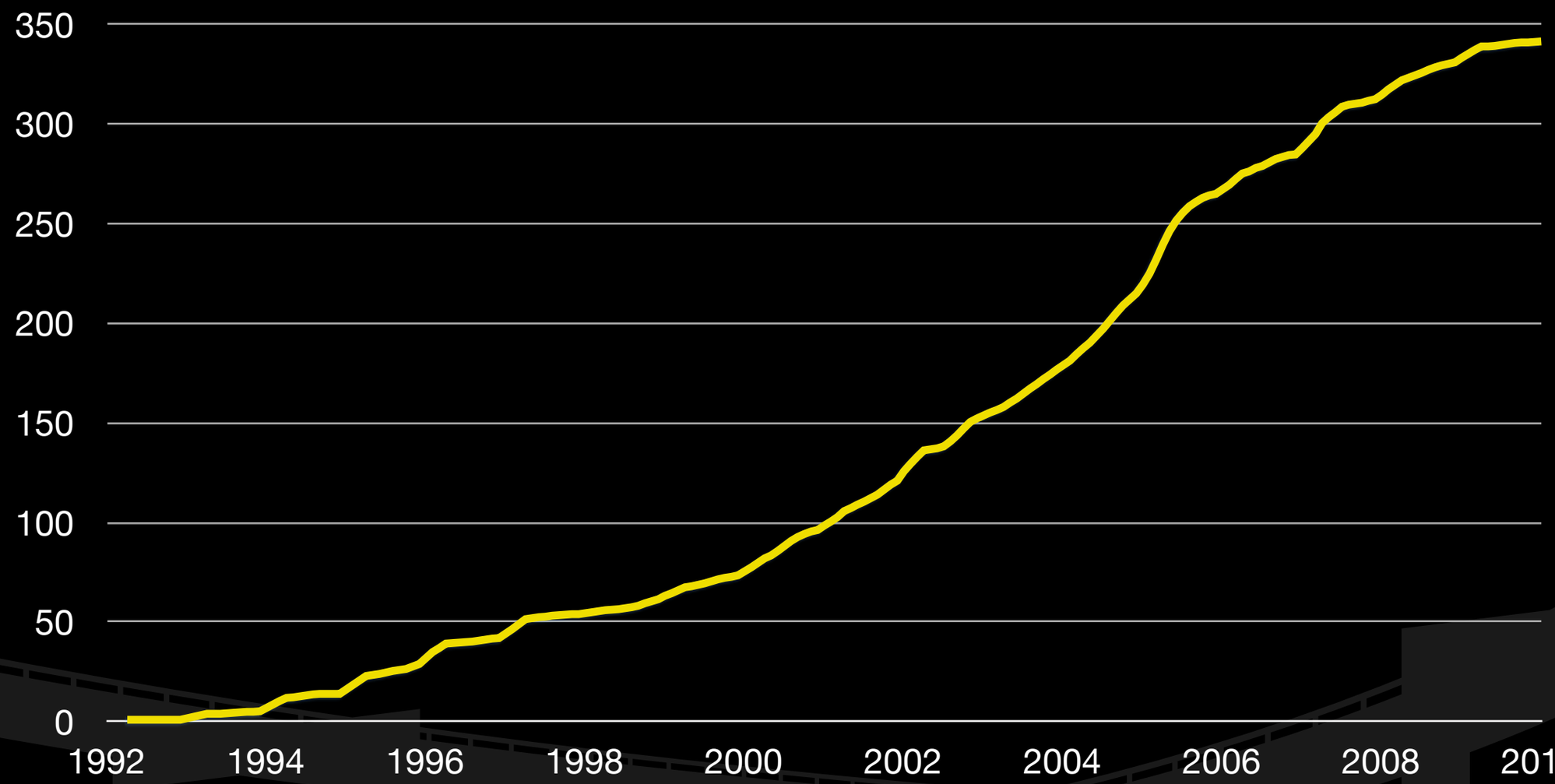
Number of IXPs



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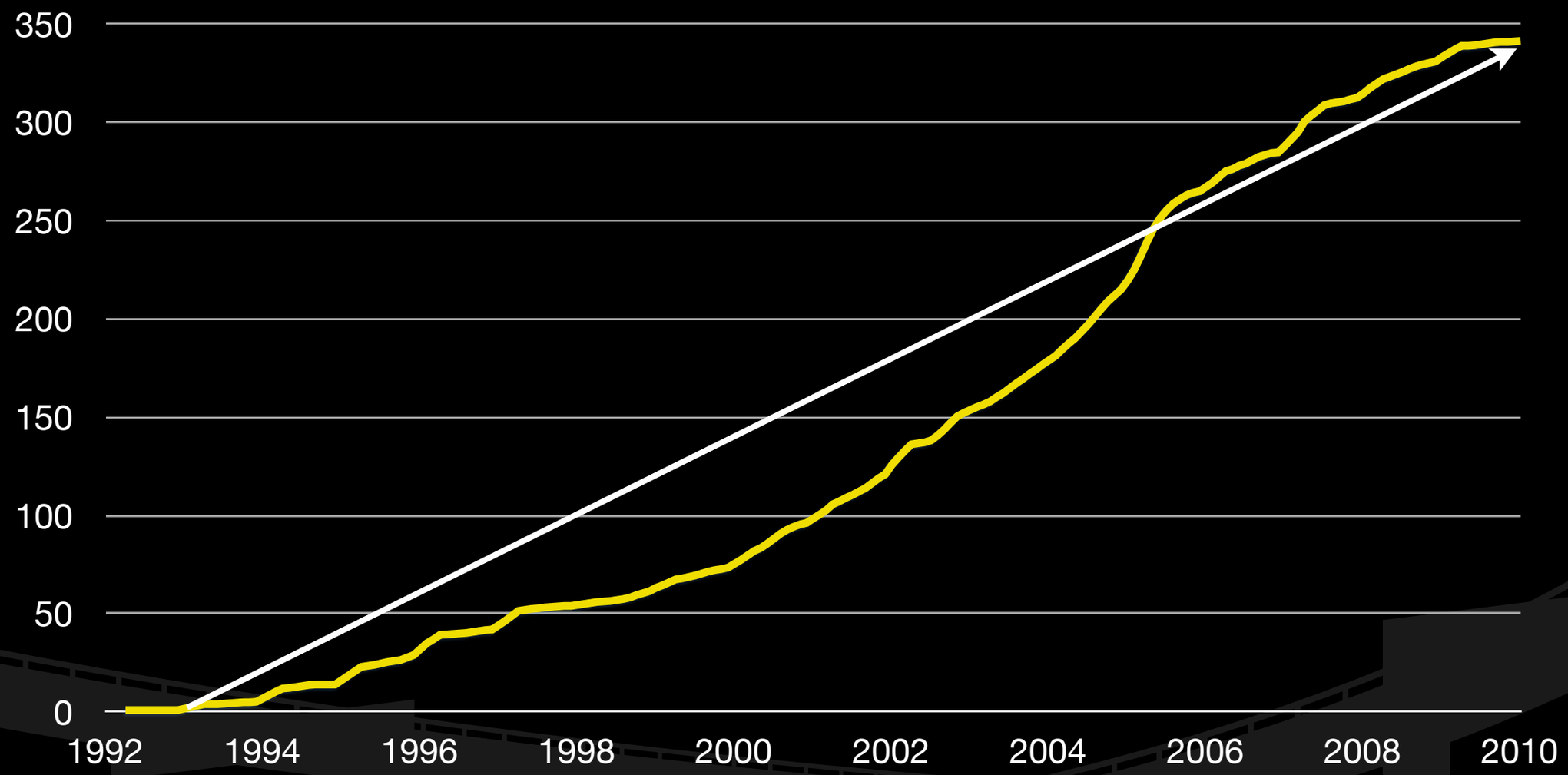

About one every three weeks

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Growth of IXP Physical Plant

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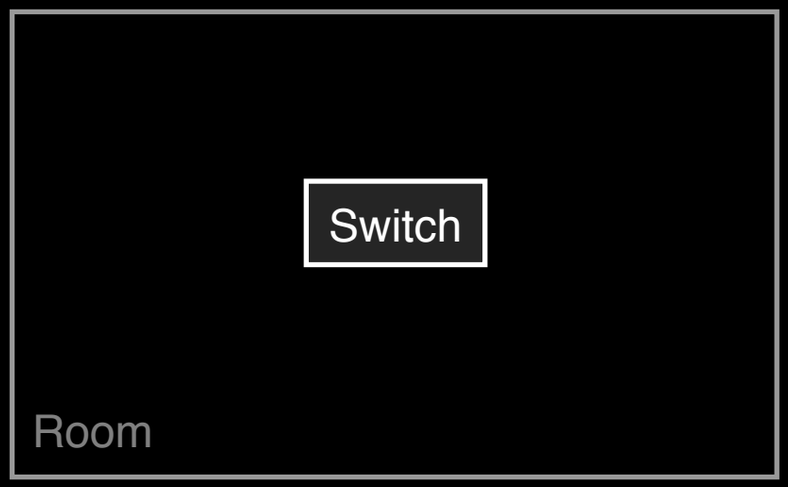
Growth of IXP Physical Plant



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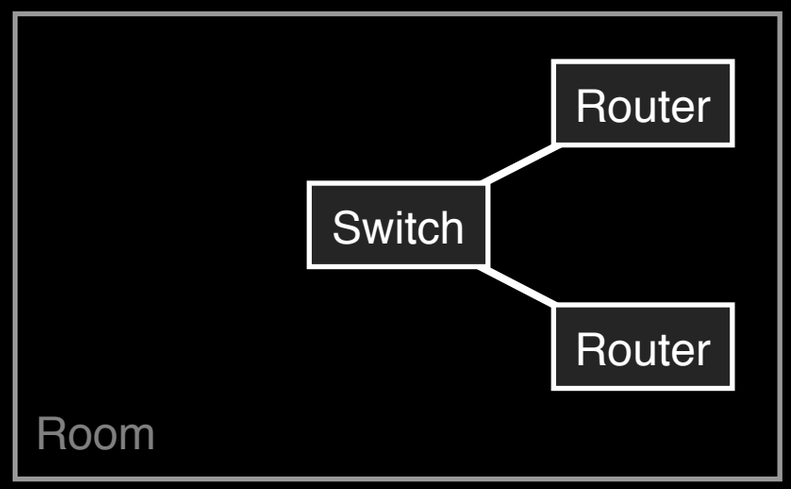
Growth of IXP Physical Plant



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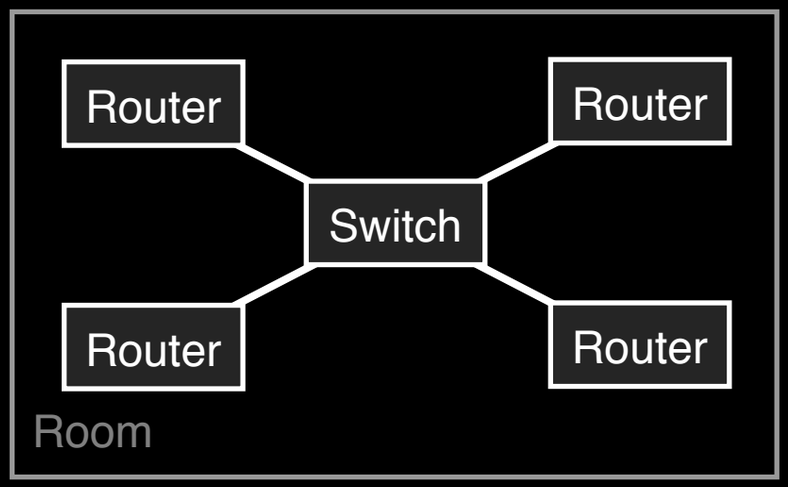

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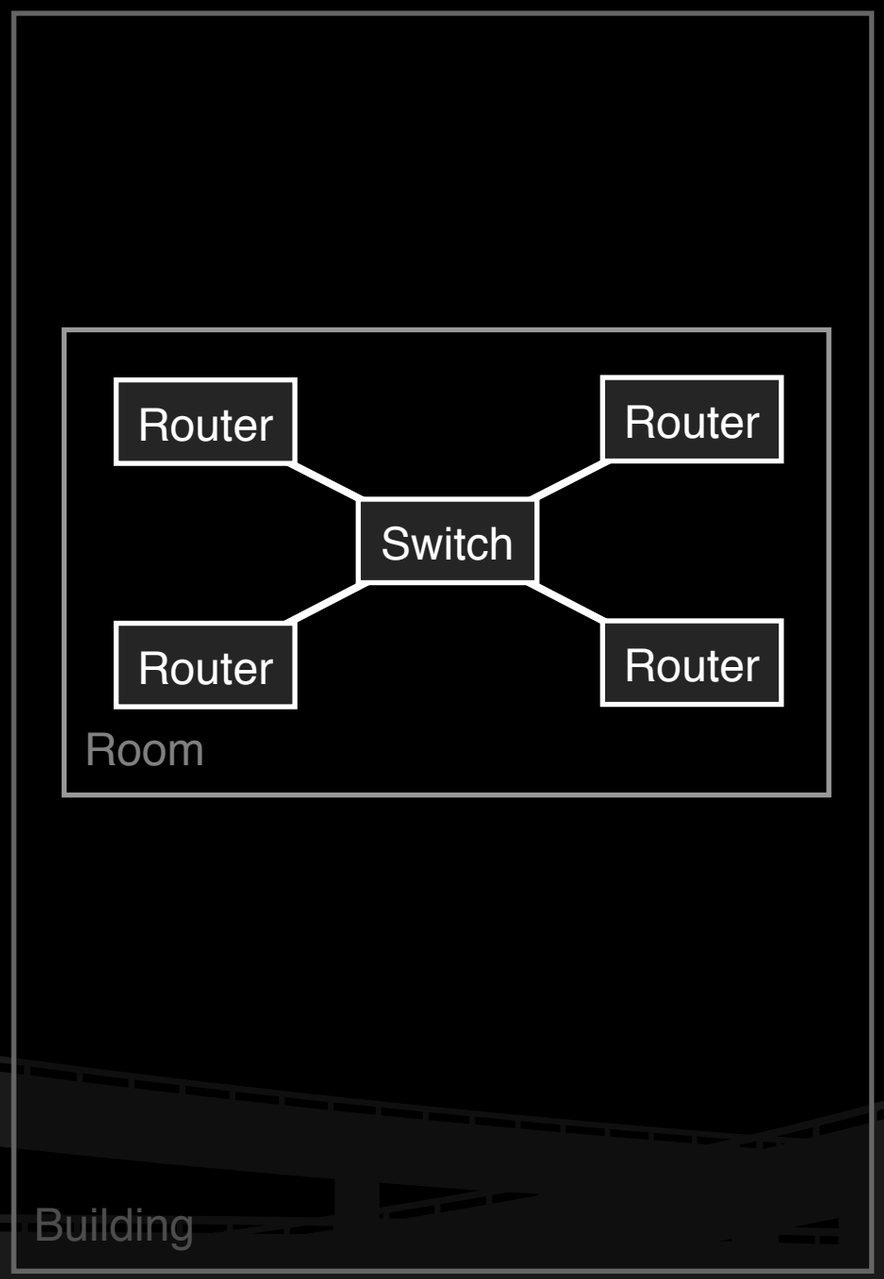

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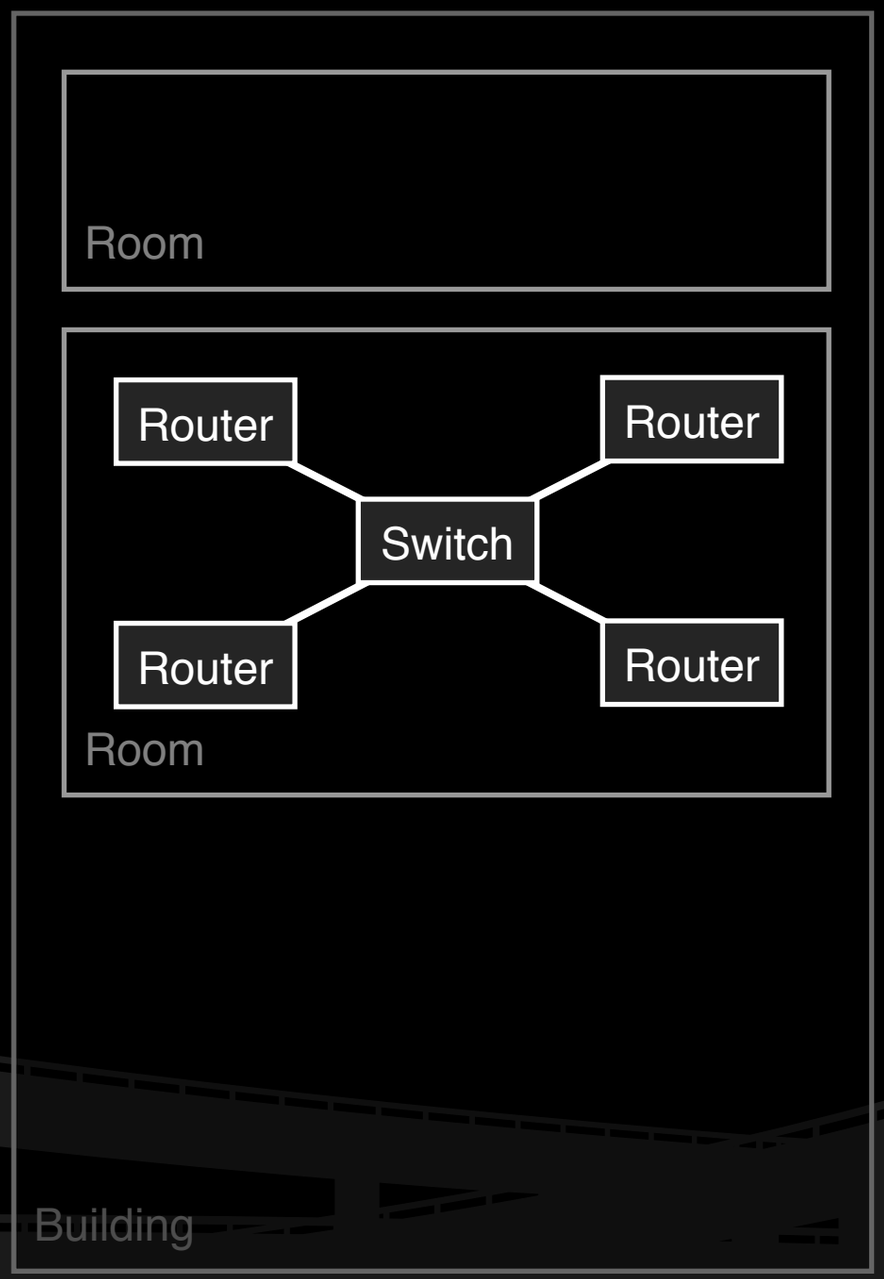

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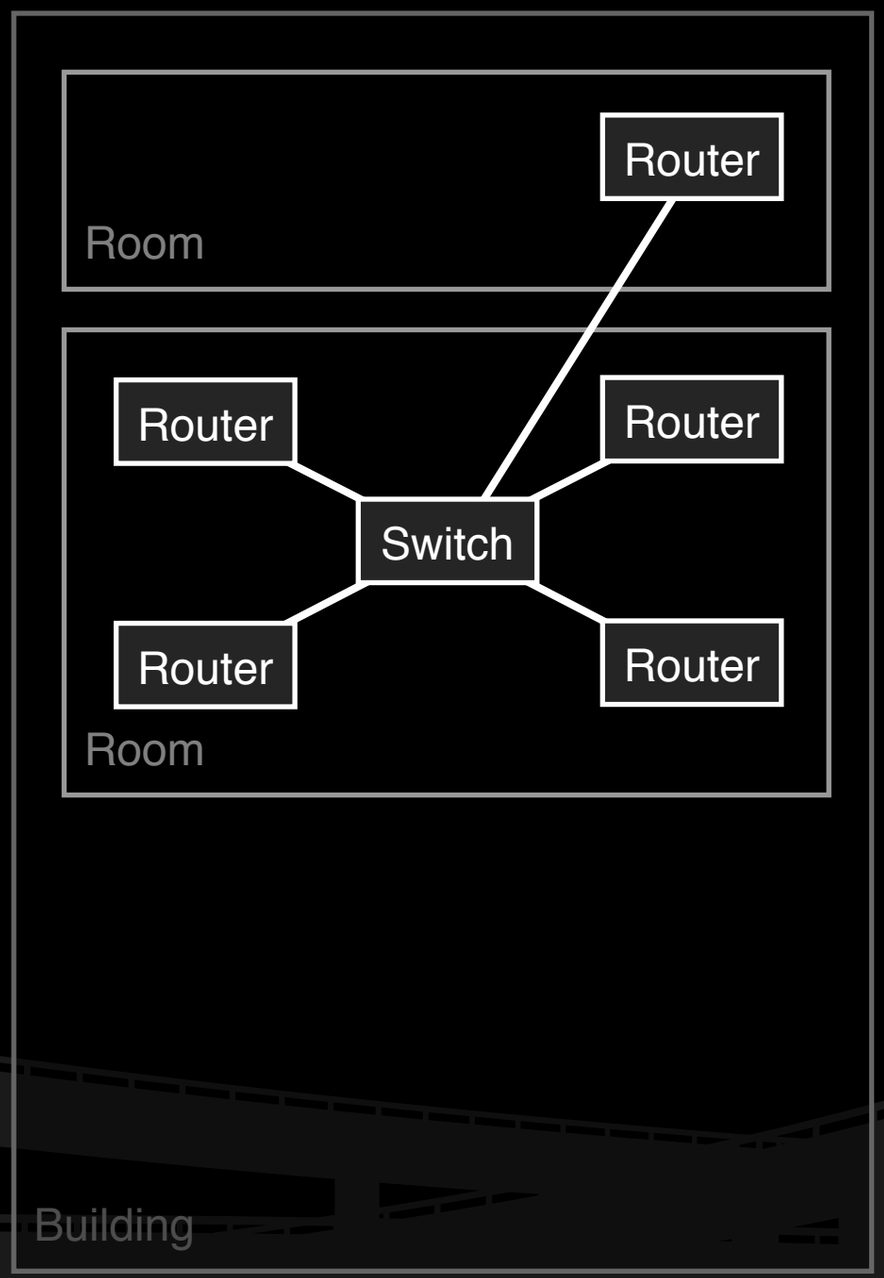

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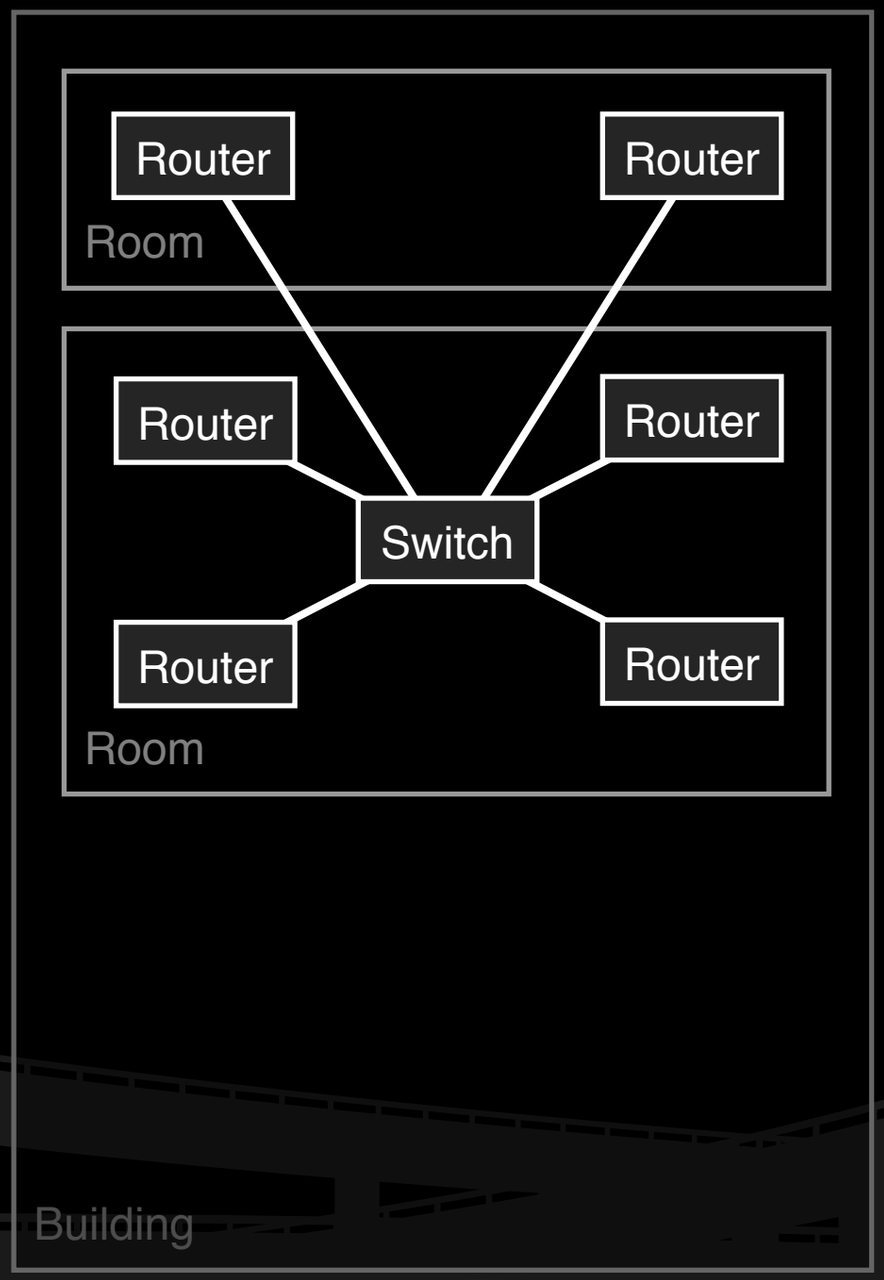

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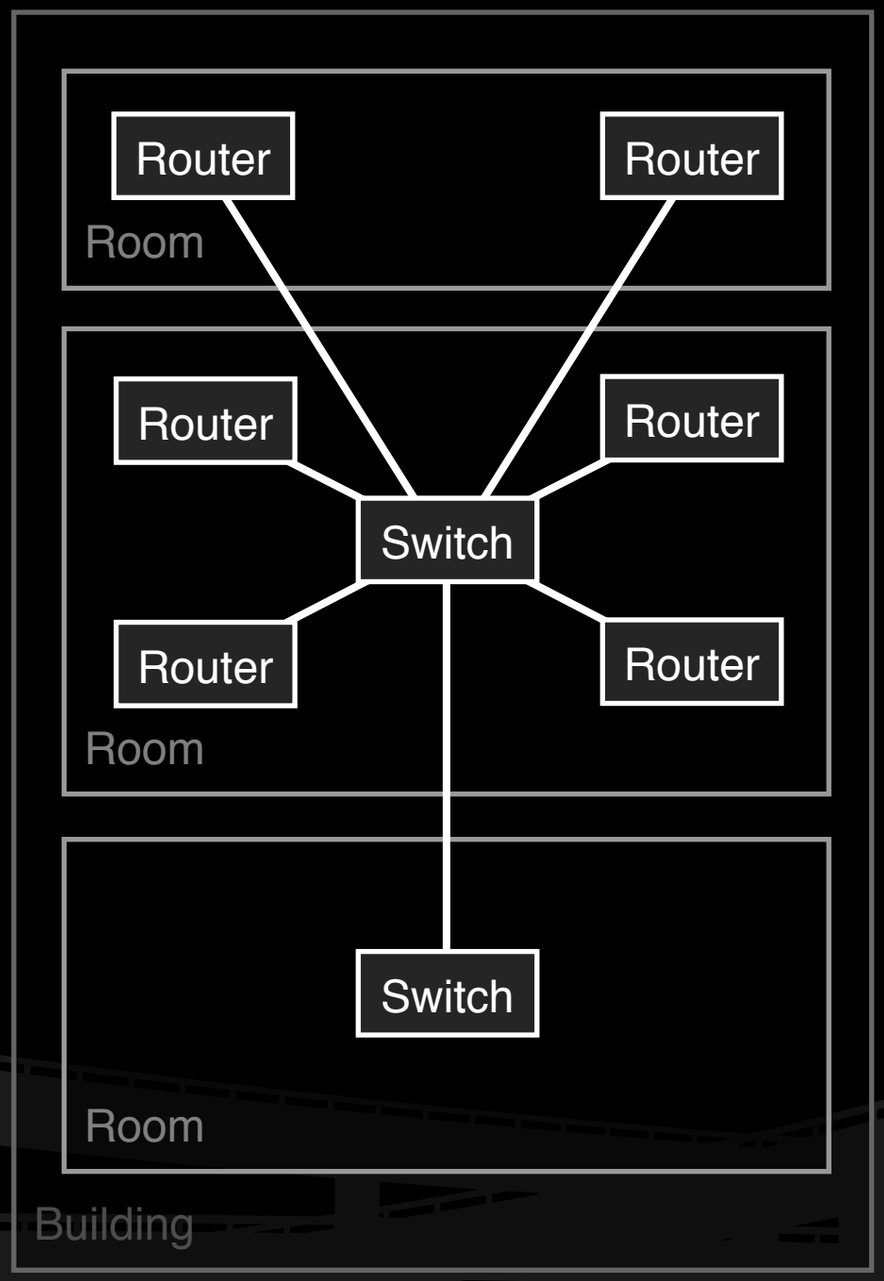

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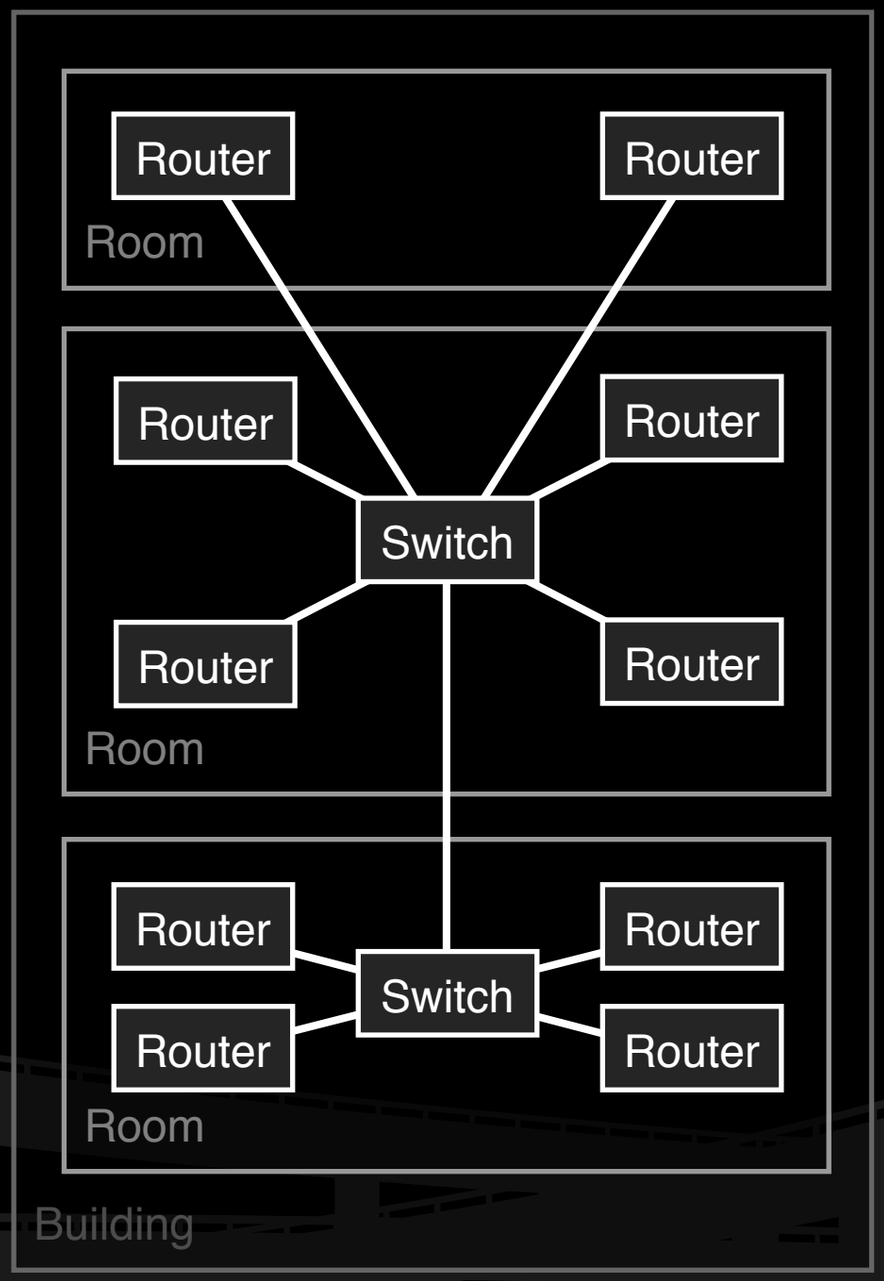

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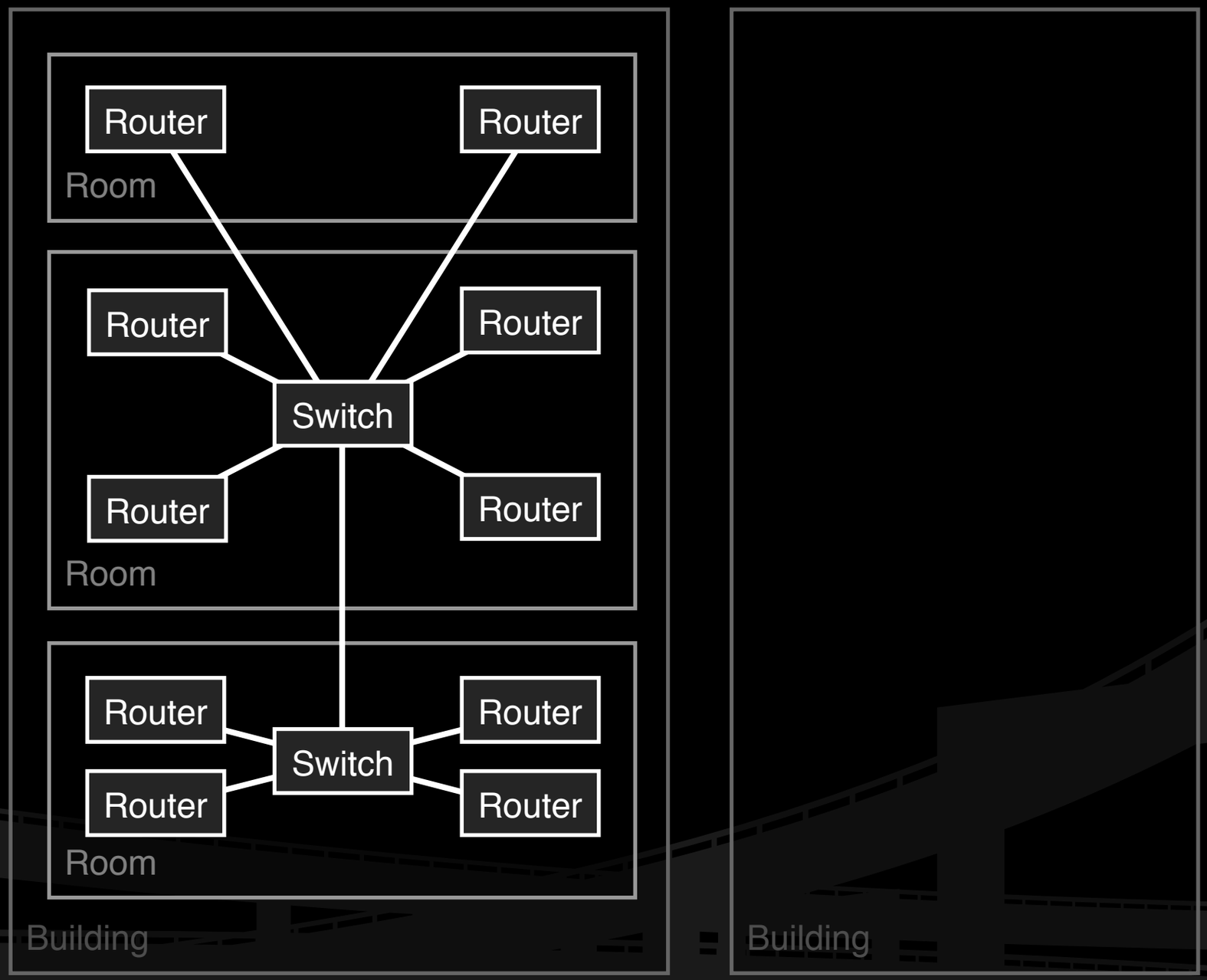

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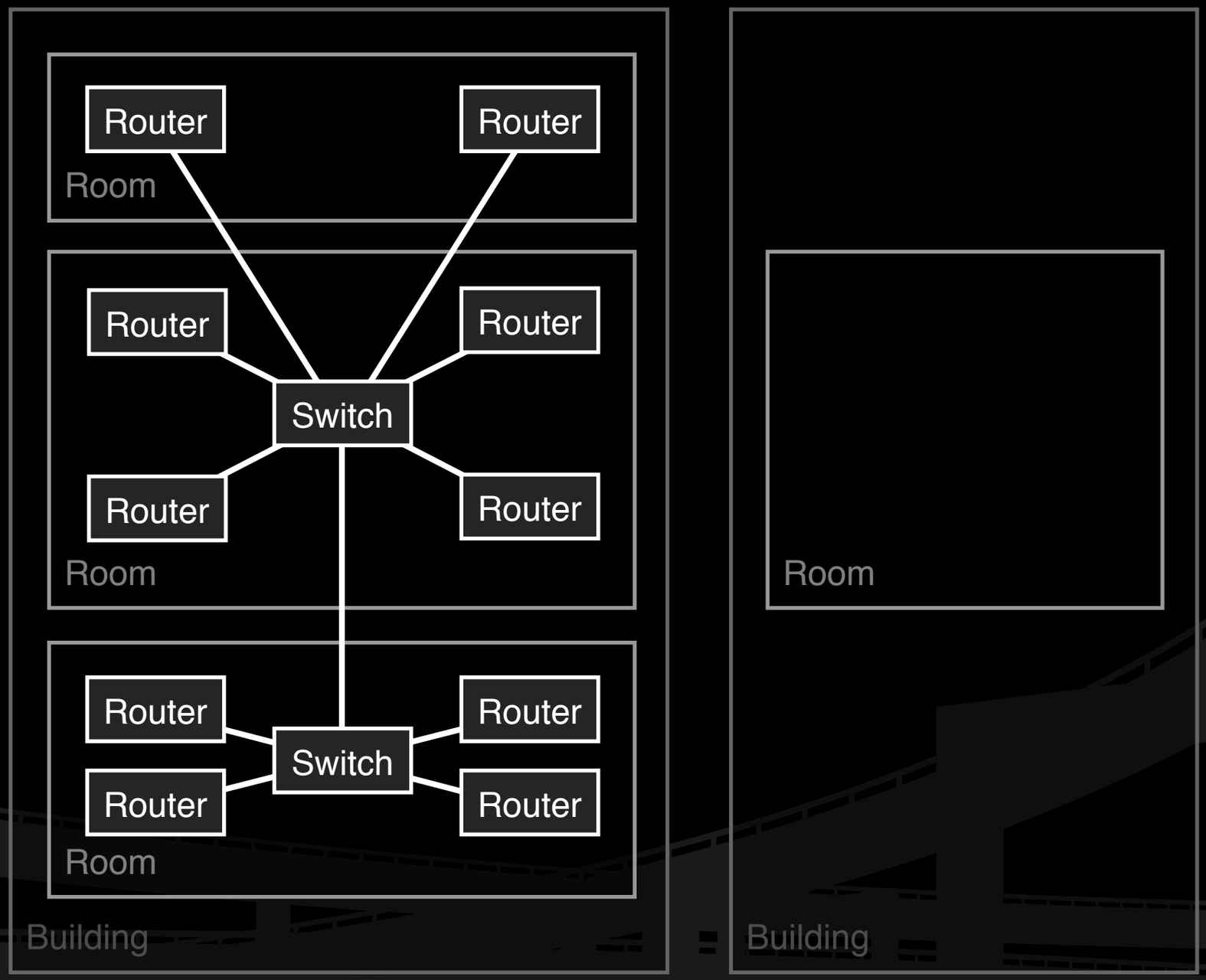

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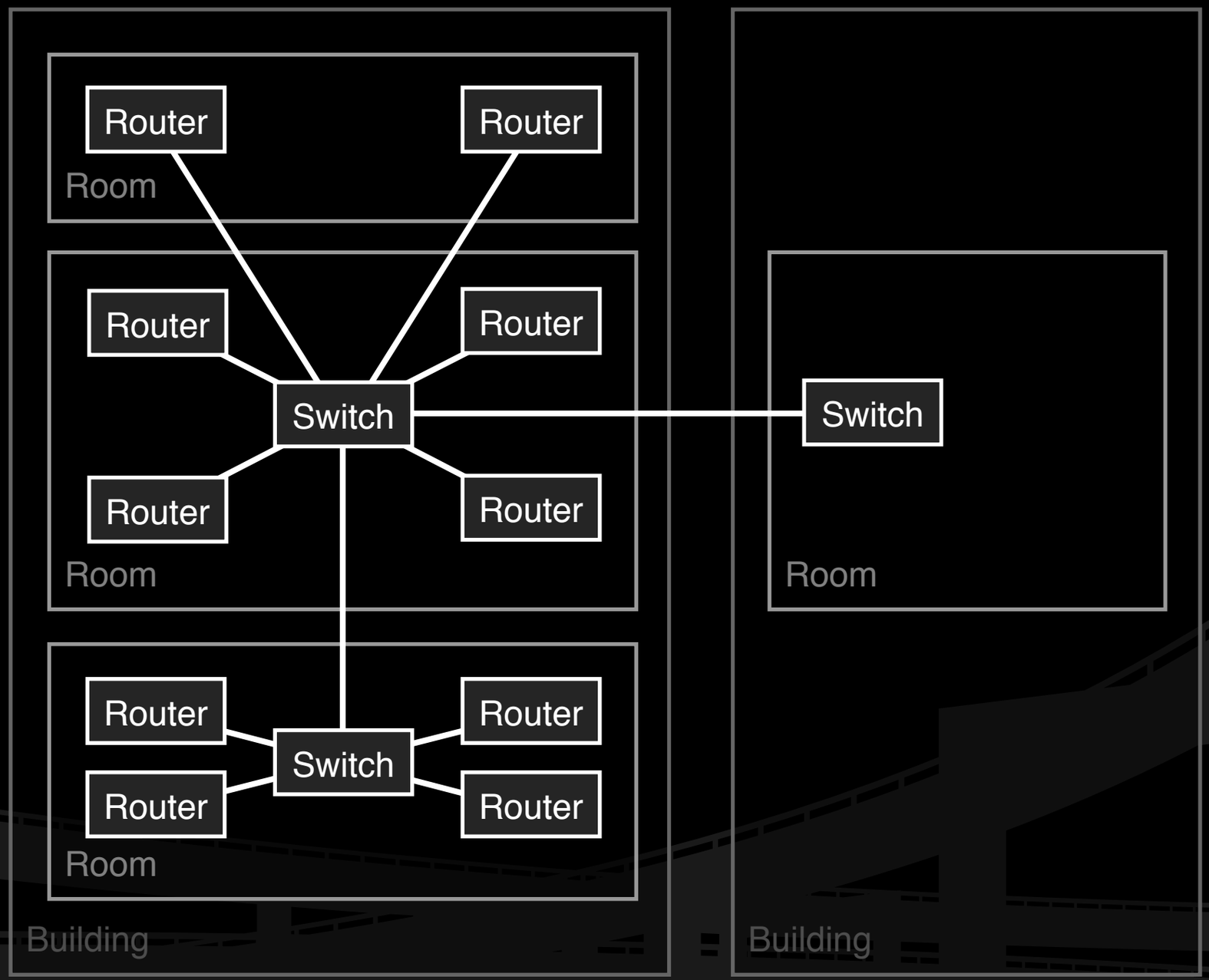

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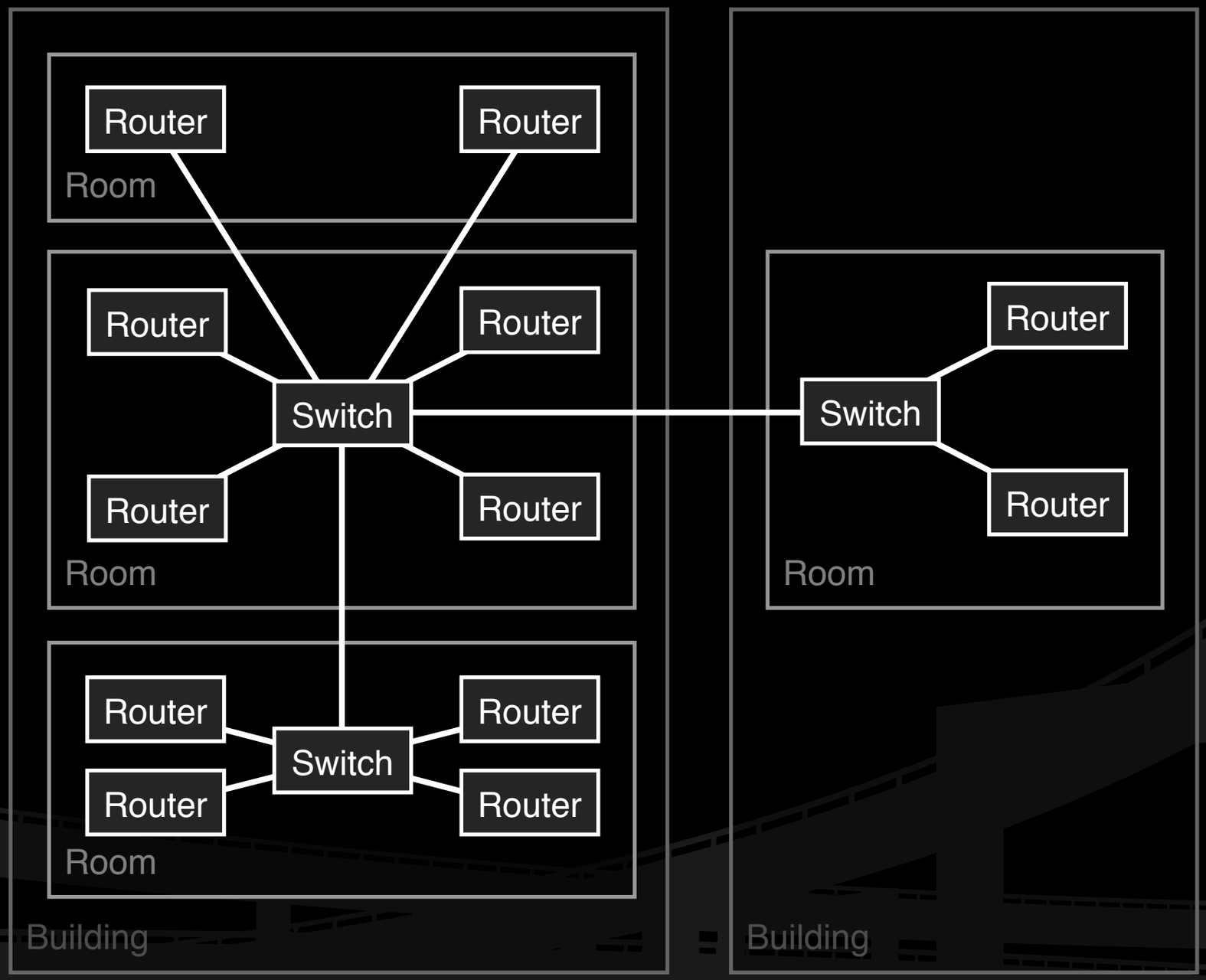

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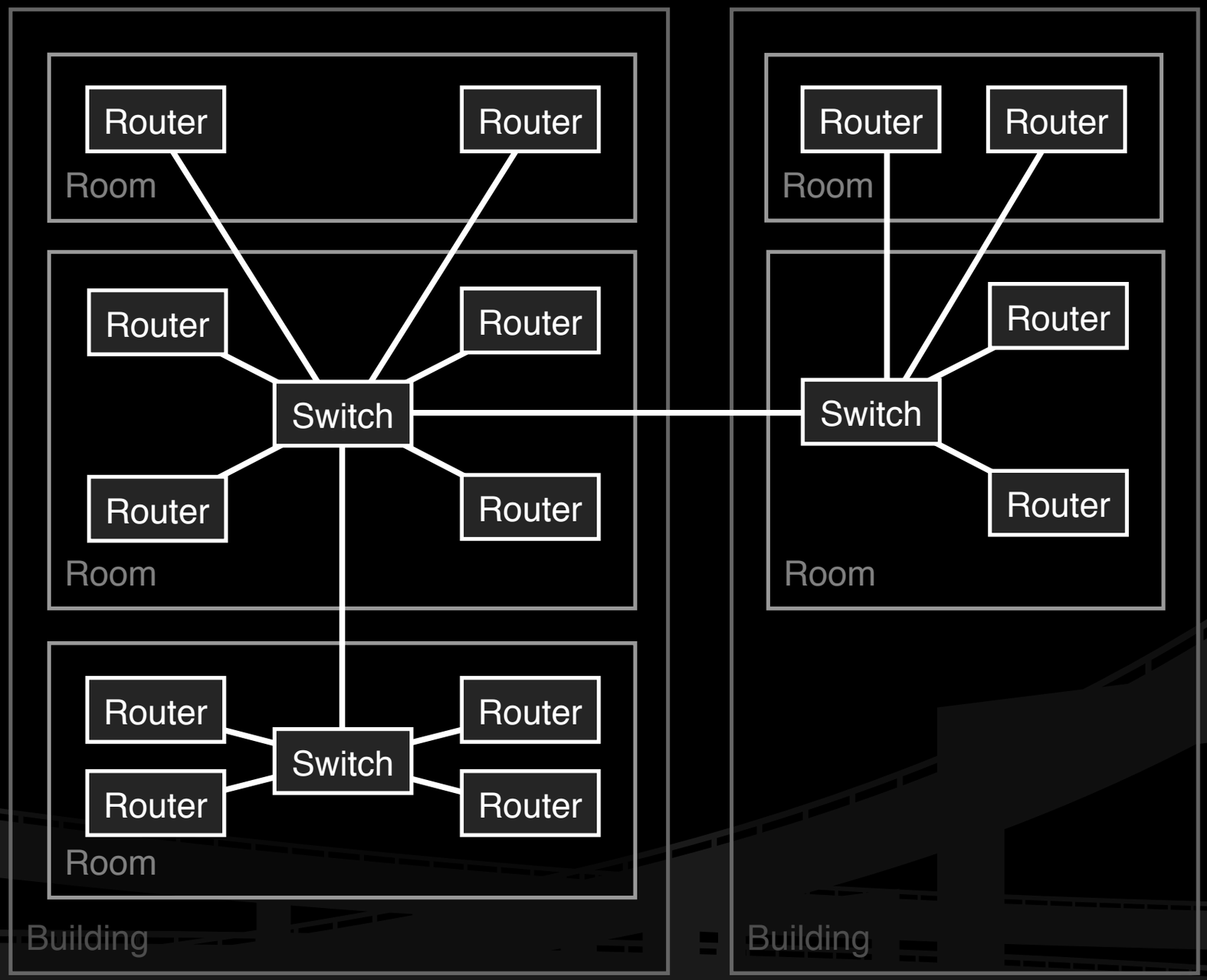

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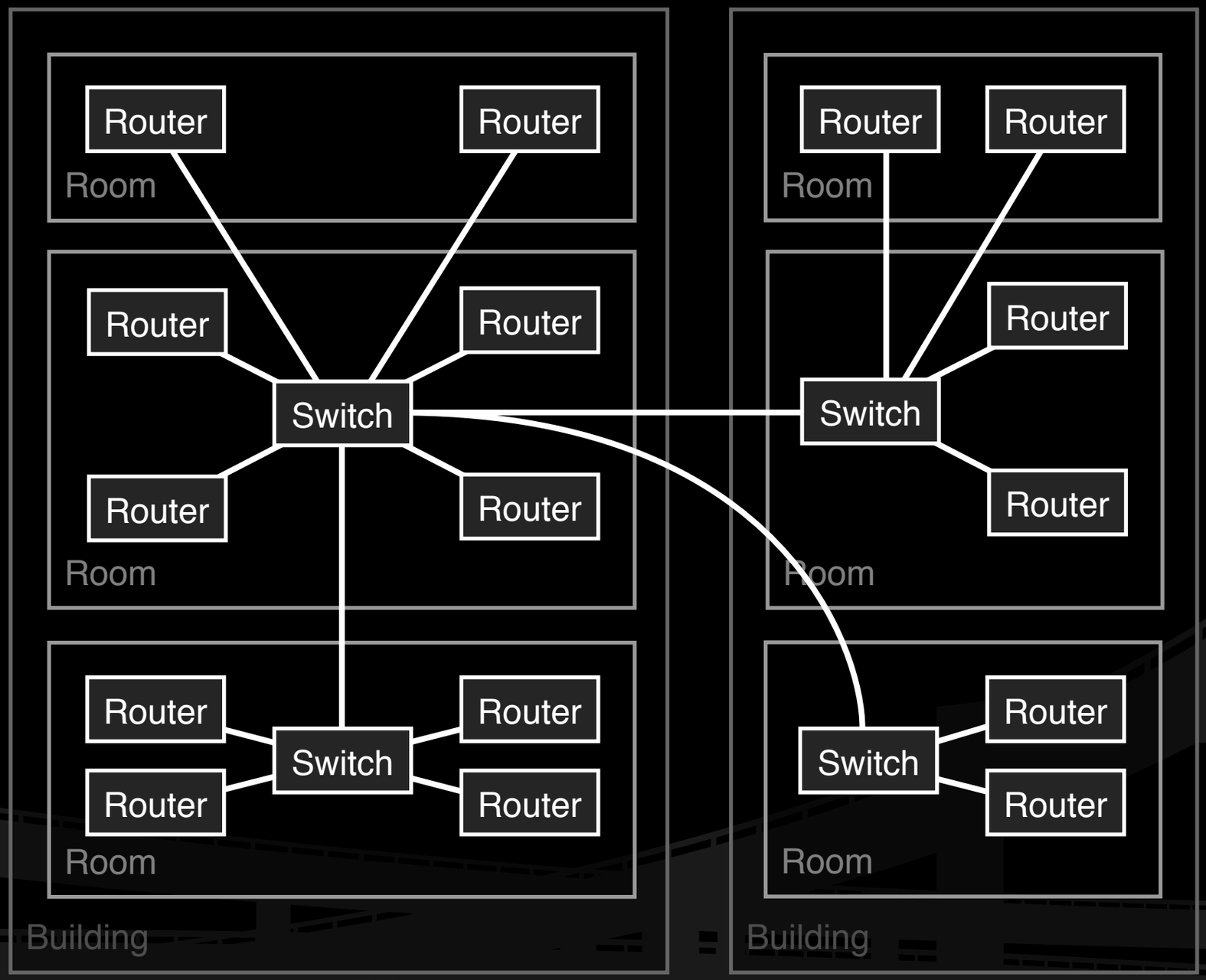

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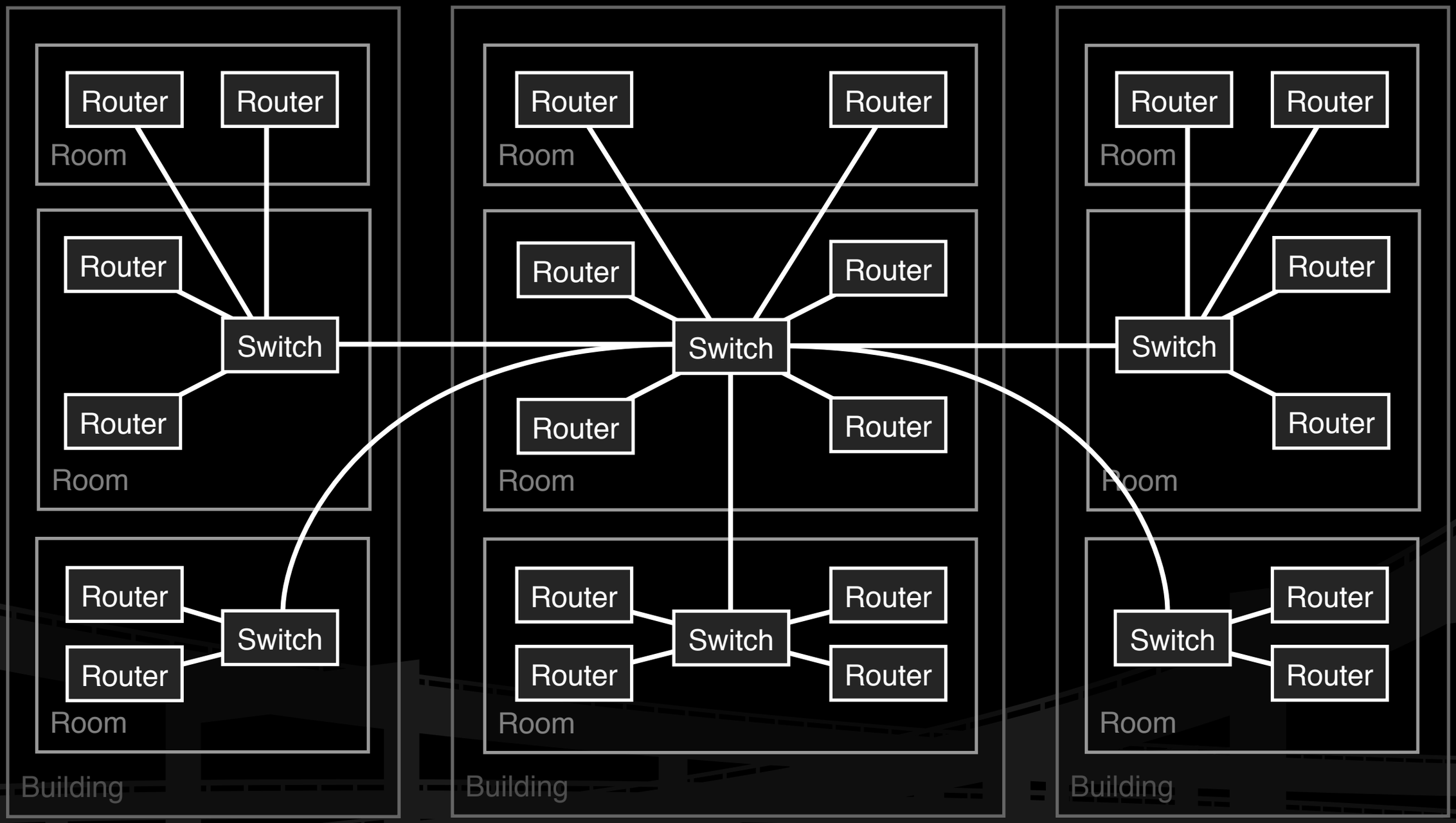

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Effect of an IX on Transit Purchase

Sometimes people assume that the introduction of low-cost bandwidth from a local IX is a literal substitute for high-cost bandwidth from existing transit providers, and that this will result in a reduction of total costs. This is not true, and stems from trying to view ISP economics in terms other than APBDC and exponential growth.

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Effect of an IX on Transit Purchase

In fact, transit contracts tend to be constrained to fixed terms, are not subject to cost-effective early cancellation, and are time- and labor-intensive to initiate.

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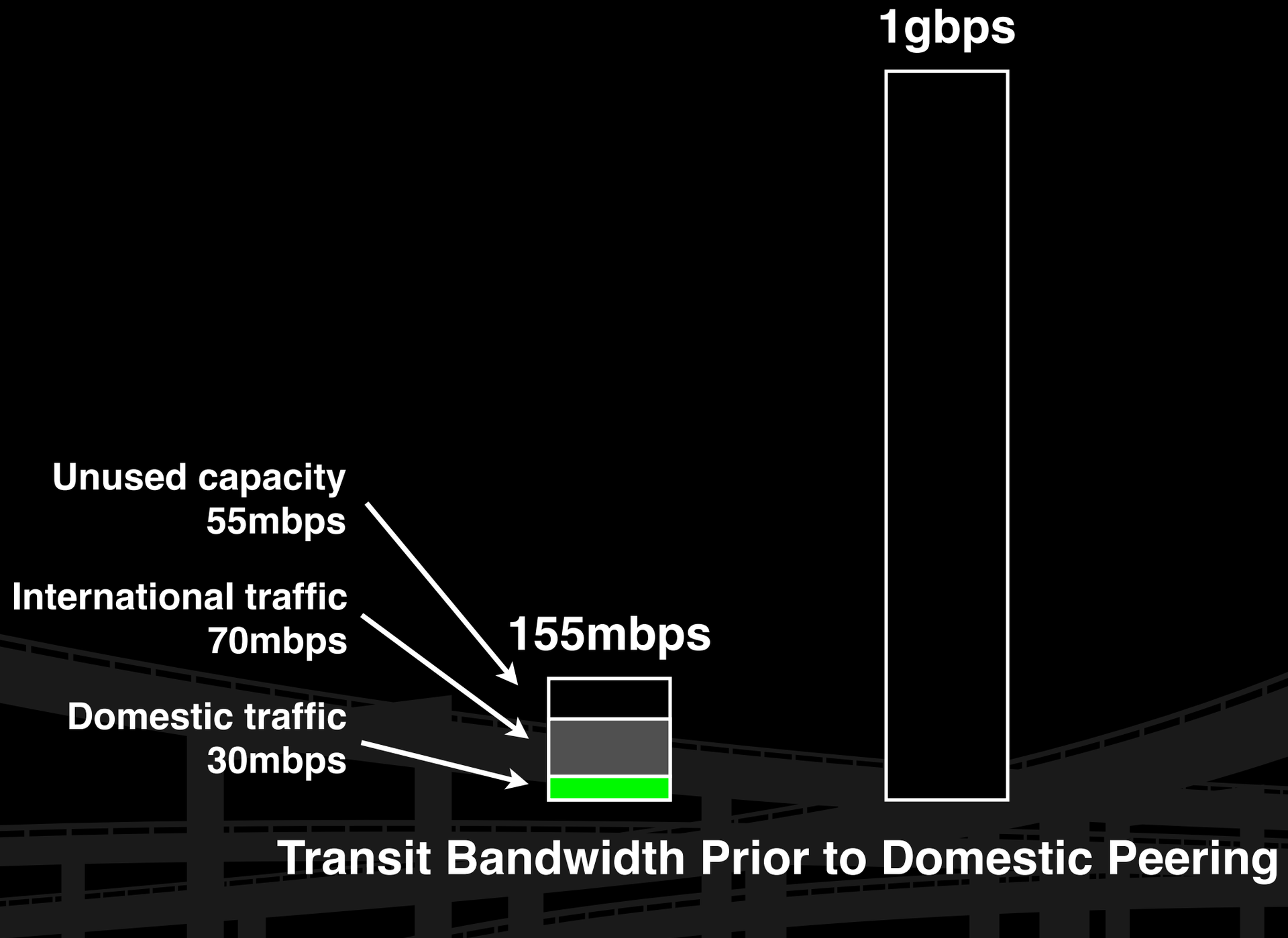
Effect of an IX on Transit Purchase



Transit Bandwidth Prior to Domestic Peering

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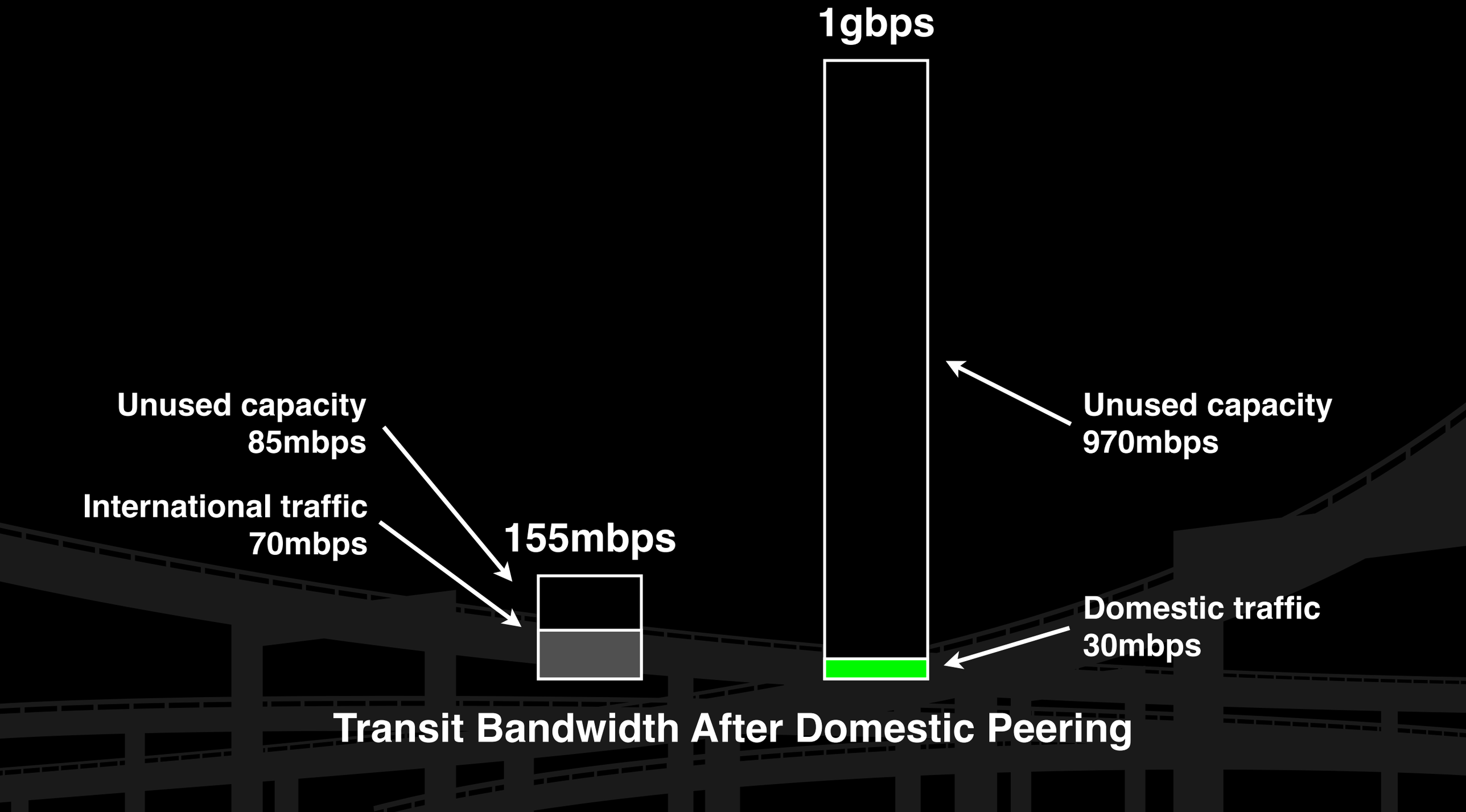
Effect of an IX on Transit Purchase



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The Virtuous Cycle of Upgrades

The Internet has doubled in size every ten and a half months for the past thirty years. Keeping up with this exponential growth is a process of addressing each revealed bottleneck and moving on to the next in a continuous virtuous cycle of upgrades, eventually returning to each bottleneck many times.

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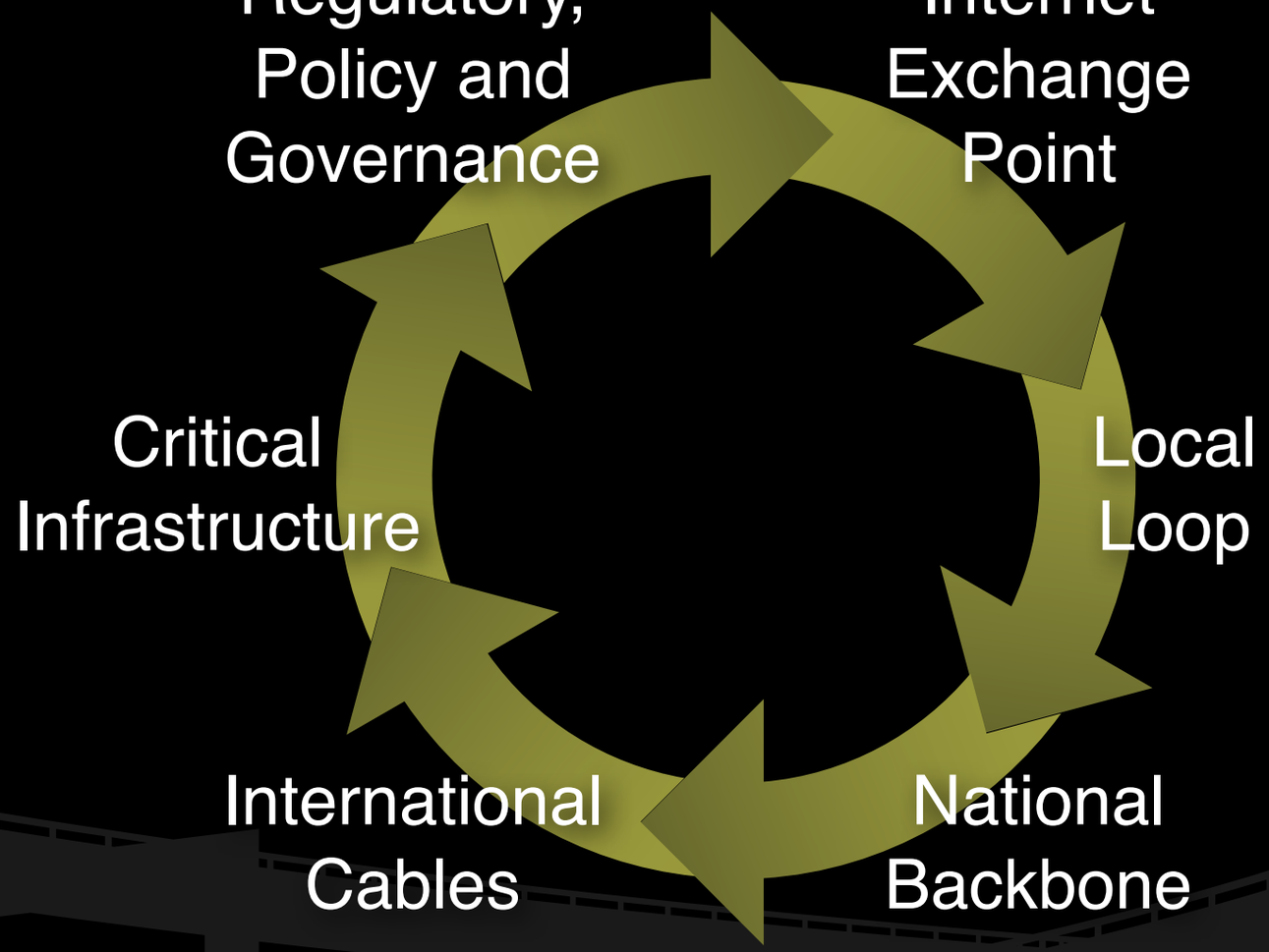
The Virtuous Cycle of Upgrades

The Virtuous Cycle of Upgrades



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The Virtuous Cycle of Upgrades

IXPs provide a domestic source of Internet bandwidth that is not dependent on International transit or transport.

The Virtuous Cycle of Upgrades

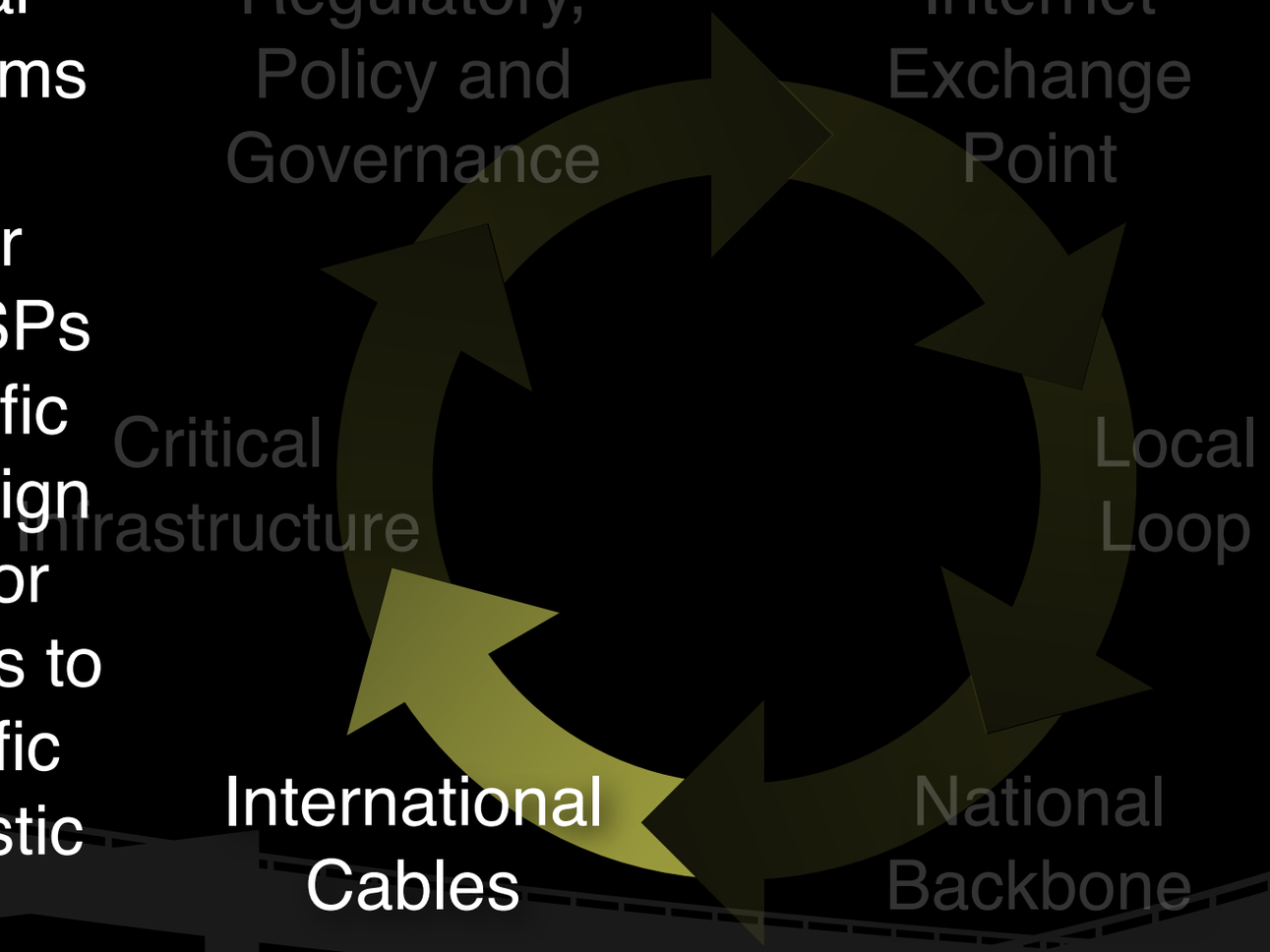
Local loops (or “last miles” of copper, fiber, or wireless must be available to connect networks to customers and resources like IXPs, critical infrastructure, and international cables.

The Virtuous Cycle of Upgrades

Long-haul backbone fiber must be available to interconnect IXPs in one city with customers in another. They form the web of circuits between a country's cities.

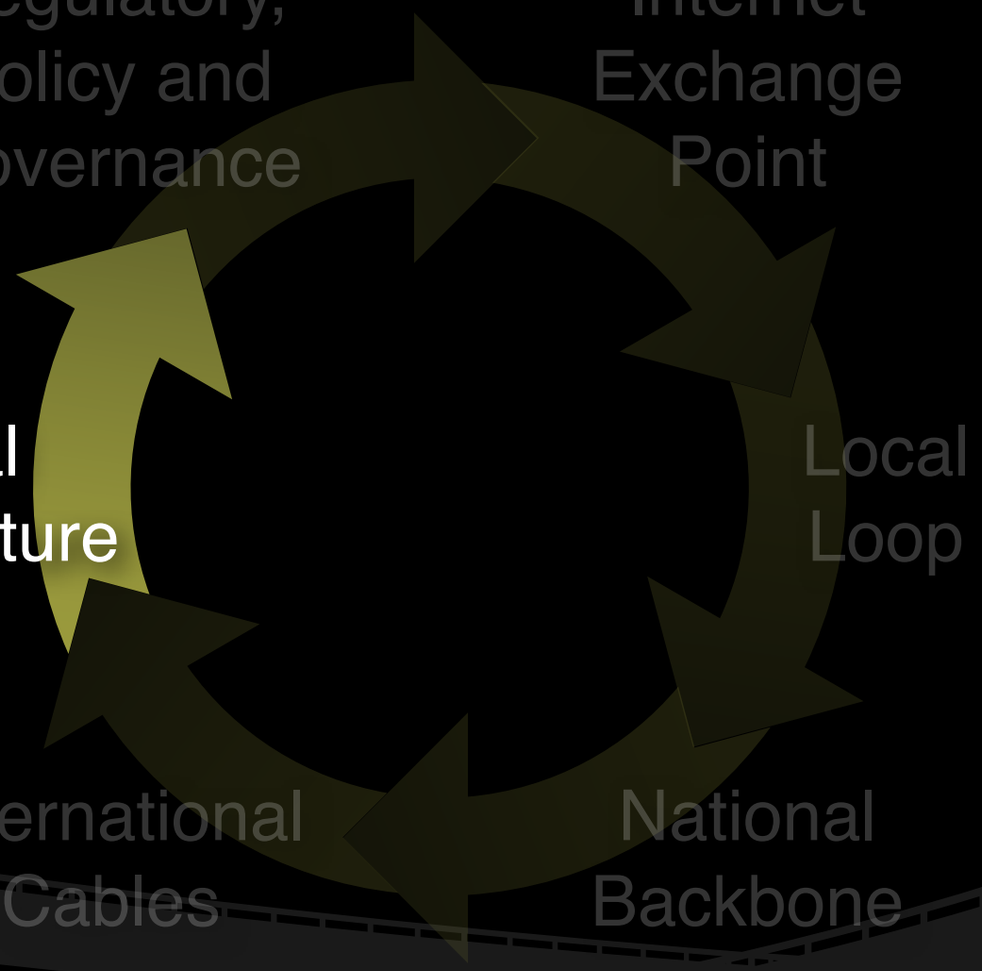
The Virtuous Cycle of Upgrades

International cable systems must be available for domestic ISPs to bring traffic in from foreign IXPs, and for foreign ISPs to receive traffic from domestic IXPs.



The Virtuous Cycle of Upgrades

Critical infrastructure like root and ccTLD nameservers, CERTs, and law enforcement intercept must be speedy enough to keep up with the rest of the network.



The Virtuous Cycle of Upgrades

The public policy environment must support and encourage new market entrants and competition among existing players to ensure continuous price/ performance improvement.

The Virtuous Cycle of Upgrades

...by which time we're ready to upgrade our IXP again.

And so on, around the circle.

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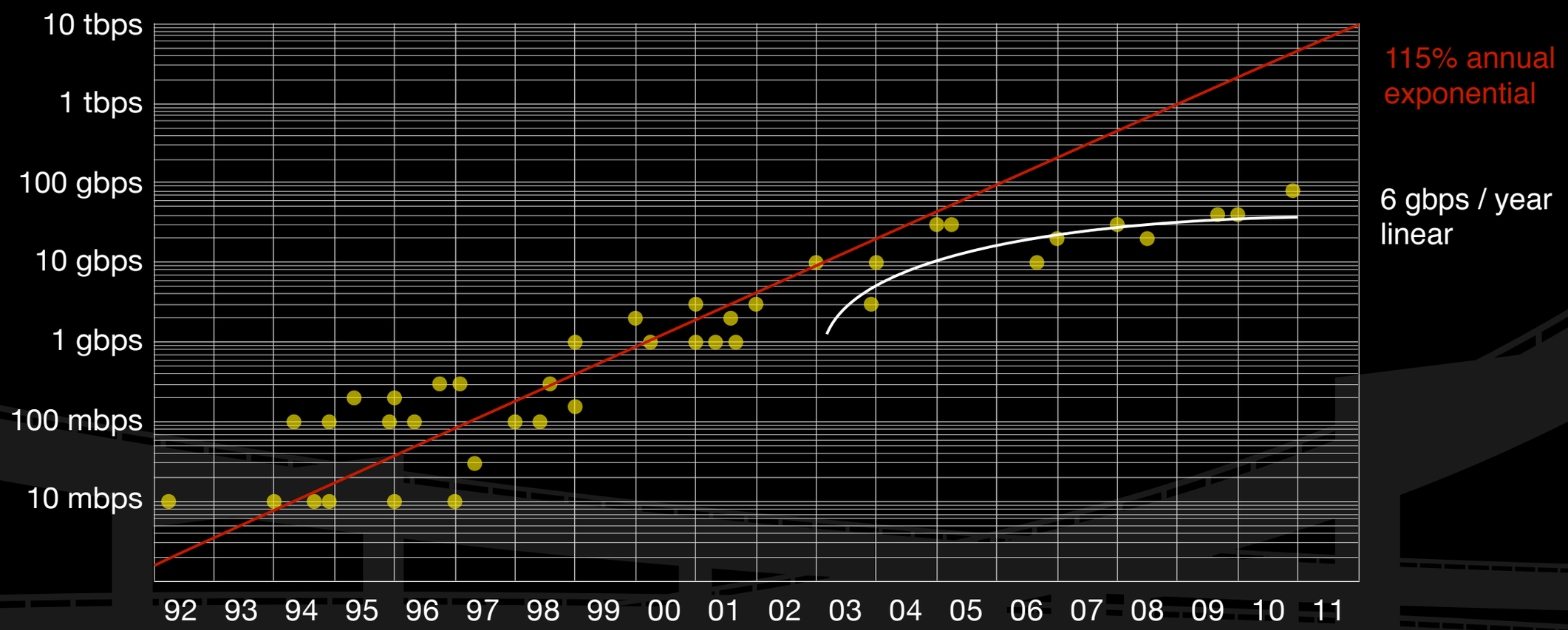
Interface Speeds Constrained

Funding for optoelectronic physics basic research was withdrawn in the wake of the 2001 telecom investment collapse.

There's a approximately four-year productization pipeline, so the effect became clear from about 2005 onward.



Thanks, and Questions?

Copies of this presentation are available in PDF format.

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