What happens when IPv4 runs out?

RIPE NCC Science Group / Tom

Not a talk about measurement

-- but may help to illuminate some new things worth measuring

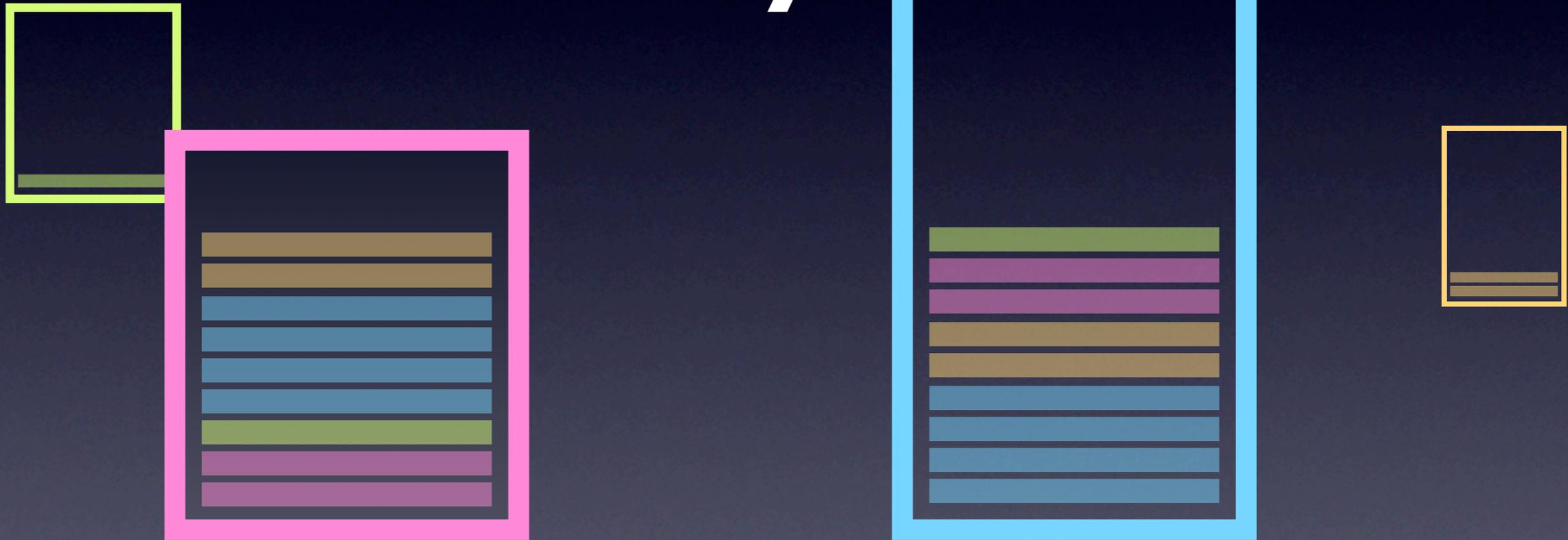# Actually, not really a talk about IPv4 exhaustion either...

...but maybe the subject will become clear before the end

What happens when IPv4 runs out?

- **More intensive exploitation of IPv4**
- **Increased use of NATs/RFC 1918 addressing**
- ***Maybe* some officially sanctioned recirculation of IPv4 (a.k.a. IPv4 "transfer markets")**
- **Regardless, some *unsanctioned* recirculation of IPv4 ("black markets")**
- **Some level of IPv6 incorporation...**

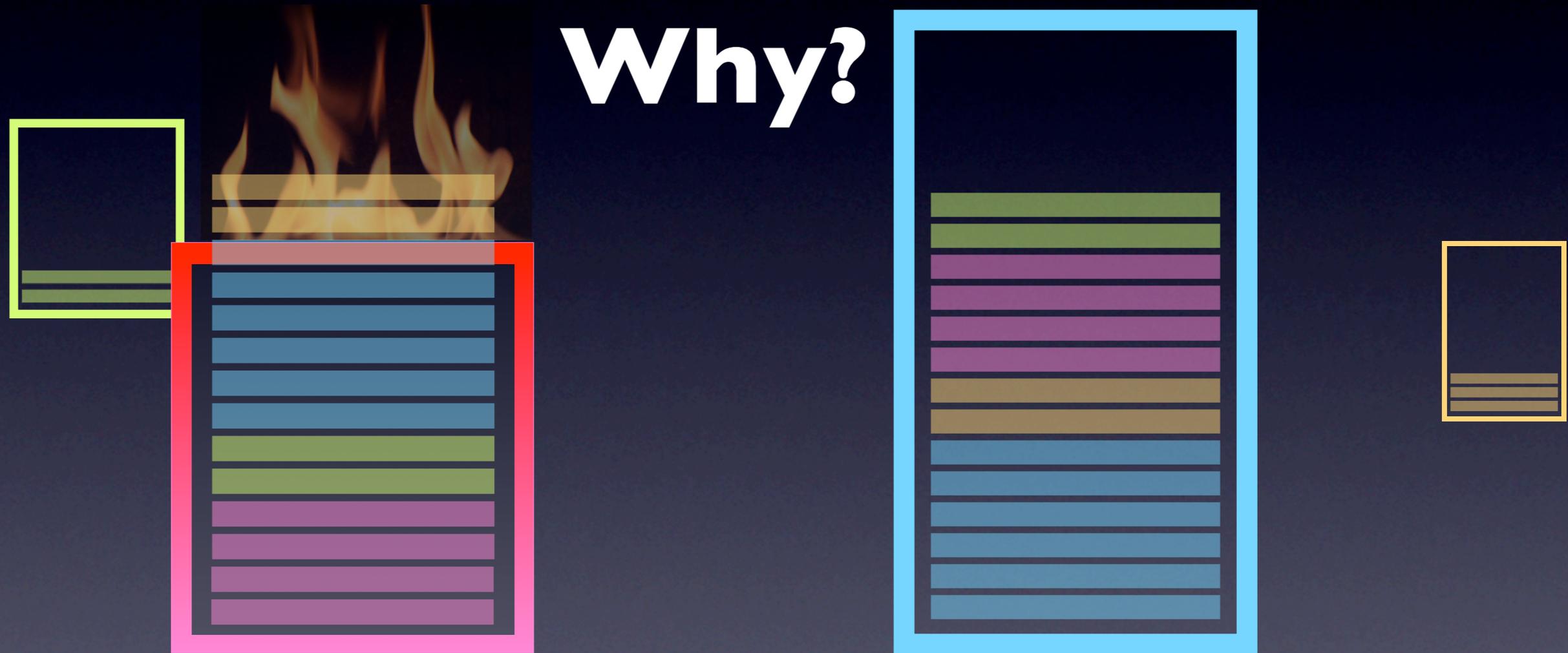# Consequence One:
Accelerated Routing Table *Bloat*
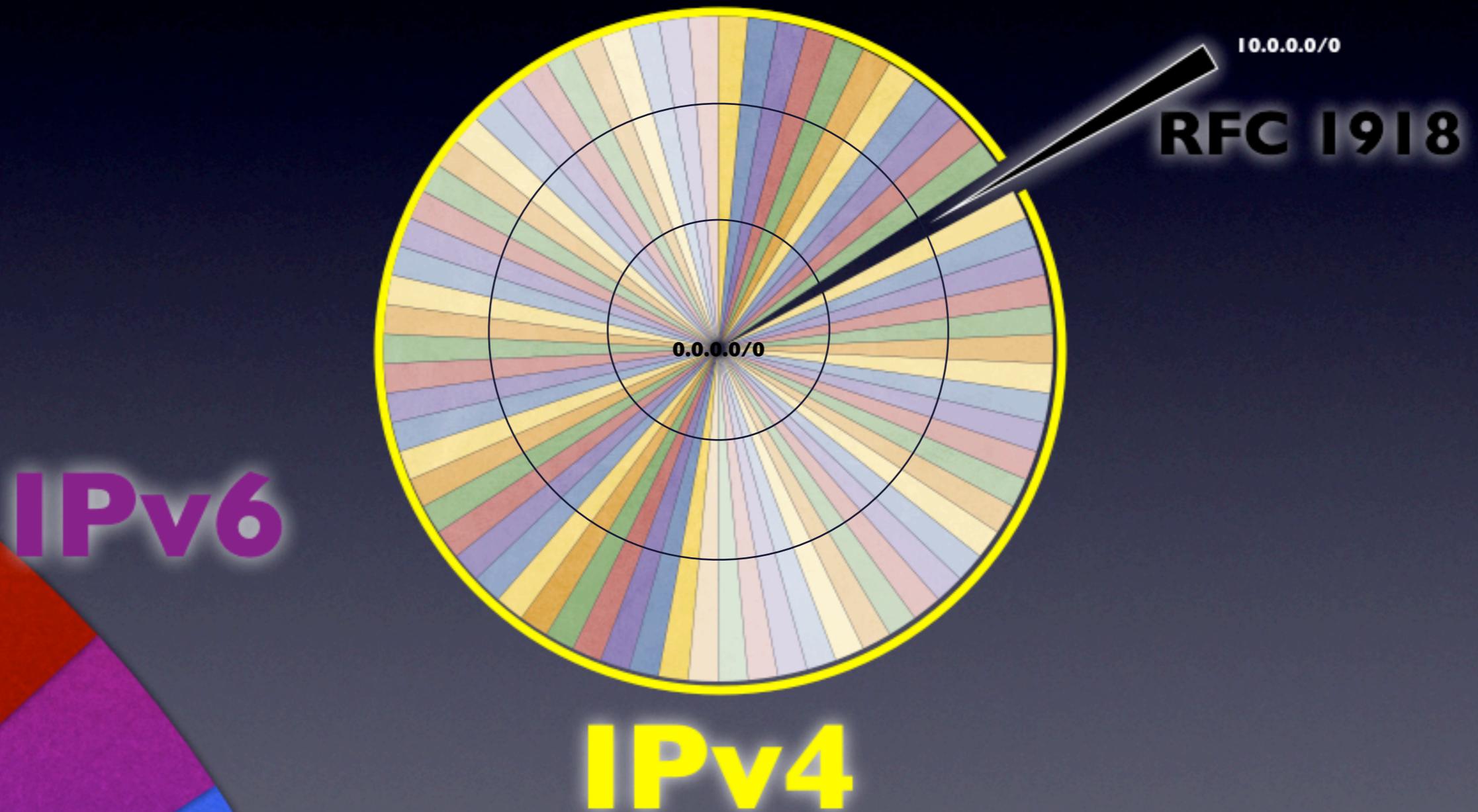
Why?

All of the same current drivers…
(new customers, multihoming, traffic engineering,
competitive pressures to satisfy customers' demands)

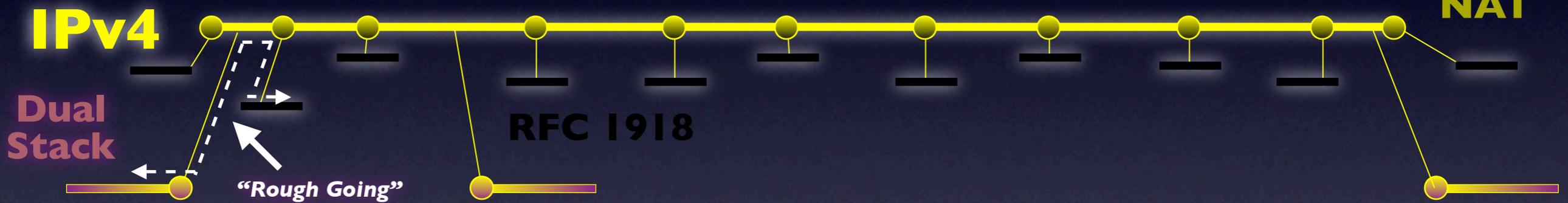# Consequence One:
Accelerated Routing Table *Bloat*

Why?

*Plus any growth that used to be aggregatable
Plus the loss of RIR "gateway" functions
Plus competition over IPv4 itself
Plus any acceleration in IPv6 uptake...*

Consequence Two:
Increased Addressing *Diversity*

IPv6

IPv4

RFC 1918

10.0.0.0/0

0.0.0.0/0

Consequence Two:
Increased Addressing *Diversity*

A "Level Paying Field"
(i.e., #translations * variety of translations * lossiness of translations = 0)

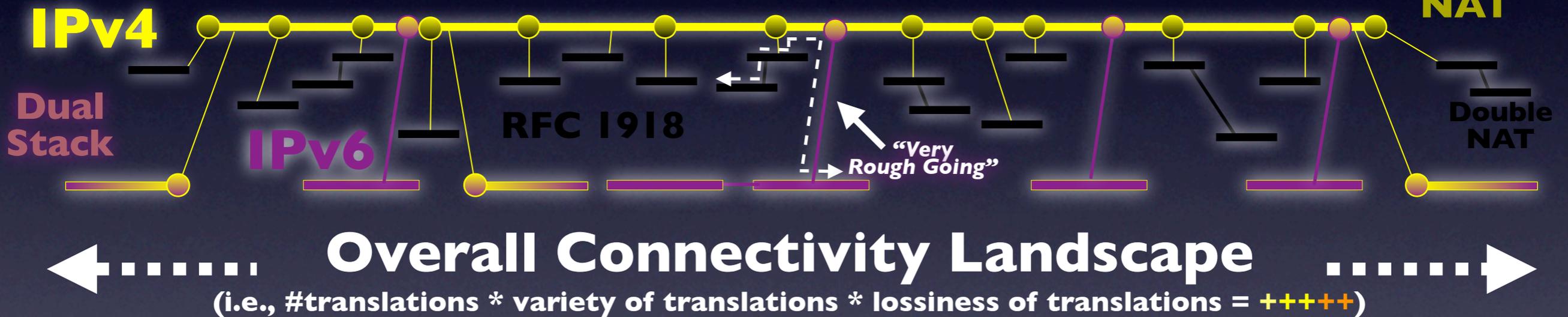**IPv4**

IPv4 NAT

Dual Stack

IPv6

RFC 1918

"Very Rough Going"

Double NAT

Overall Connectivity Landscape
(i.e., #translations * variety of translations * lossiness of translations = +++++)

Why?
Plus increased cost of IPv4 specifically
Plus eventual unavailability of IPv4
Plus mutual isolation of most IPv6 domains

Put them Together:
What do you get?

- Routing customers happy *(or at least less unhappy)*
- Aggravated by any/all provider responses *(apart from persuading customers to not want what they want, i.e., aggregation and/or NAT)*
- **Cost of operations increases**

- Access customers unhappy
- Increasingly rugged, unpredictable interaction, (packet) exchange landscape
- Increased costs, for content/service providers to reach all end users
- **Diminished incentives for all parties to produce, innovate**

Put them Together:
What do you got?

- Routing customers happy *(or at least less unhappy)*
- Any/all provider responses *(apart from persuading customers to not want what they want, i.e., aggregation and/or NAT)*
- **Cost of operations rises**

"Inflation"

- Access customers unhappy
- Increasingly rugged, unpredictable connectivity, (packet) exchange landscape
- Increased costs, for content/ service providers to reach all end users (as well as e2e)
- **Diminished incentives for all parties to produce, innovate**

"Stagnation"

Put them Together:
What do you got?
"Stagflation"

- **An economic system that cannot grow its way out of trouble**

- **Troubles that cannot be attacked in isolation, because addressing one dimension aggravates the other**

- **Economic grievances that often spill over into other domains (e.g., governance)**

- **The most frequently cited cause in (all) other sectors: EXOGENOUS SHOCK -- i.e., sudden sharp rise in a critical, non-substitutable input... sound like IPv4?**

Anything sound familiar yet?

- **What do inflation and stagnation have in common?**

- **How did we (at least try to) avoid these problems before now?**

- *RFC 2050: "fair distribution of resources... in a manner permitting routing scalability"*

- **What made the point-source of address distribution a good place to establish the baseline for routing scalability?**

Are IP addresses just another production input?

- **Not useful in any other context**

- *Very* **useful in that context, as key to durable access to other TCP/IP functions**

- **Standardized packet encapsulation makes diverse content, services, etc. accessible over a single system, which in turn makes opportunistic, non-specific exchanges easy...**
  no *"double coincidence of wants"* necessary

Anything sound familiar yet?