The Cost of Carrier-Grade NAT

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Introduction

- Thought experiment: How to quantify the total cost of CGN?
  - CapEx
  - OpEx
  - Breakage
- What are the implications of that cost?
- US dollars, other U.S.-centric perspective
- Detailed paper, spreadsheet available at

  http://www.asgard.org/documents.html

What Does CGN Cost?

$70,000	CGN hardware
$10,000	Logging systems
$10,000	Software development
$90,000	CAPEX per 10,000 users

$10,000	Space, power, cooling, monitoring, maintenance, etc.
$10,000	OPEX per 10,000 users

What Does CGN Cost?

- CGN reportedly breaks things[1]
- How many users affected (out of 10,000)?

Use	Number of Potential Users[2]	Number Affected	Number of Support Calls[3]	Number of Lost Users[3]
PS3	1100	550	137	137
P2P	1500	1200	300	300
Netflix	1200	60	15	15
Misc.	800	800	200	200
	6,700	2,610	652	652

[1] draft-donley-nat444-impacts
[2] North American sales per ten thousand homes, per various sources.
[3] Arbitrary guess. Spreadsheet at http://www.asgard.org/documents.html

- For each 10,000 users:
- If support call cost is $20, the increased support cost is
  $20 * 652= $13,040.
- If (ARPU) is $400/year, the total revenue lost to CGN is
  $400 * 652= $260,800 per year.

Total CGN Costs per 10,000 Users
(USD)

Year 1	Year 2	Year 3	Year 4	Year 5	
$18,000	$18,000	$18,000	$18,000	$18,000	CAPEX (depreciation)
$10,000	$10,000	$10,000	$10,000	$10,000	OPEX
$13,040	0	0	0	0	Customer support
$260,800	$260,800	$260,800	$260,800	$260,800	Lost revenue
$301,840	$288,800	$288,800	$288,800	$288,800	TOTAL: $1,457,040

Detailed paper at http://www.asgard.org/documents.html

Conclusion #1

CGN costs US$1.5 million for every 10,000 users it's used for, or $30 per user per year.

Would it be cheaper to buy addresses?

- From $12 - $30 per address, IPv4 addresses look cheaper than CGN
- Above $30, CGN is cheaper than each address

When is CGN too expensive?

- According to annual reports of major US ISPs, ARPU is $400 for Internet access, and margin is about $140 per user

- If you have to spend $70 to make $140, it's more profitable to sell addresses than to turn up customers
  - At least in the 1-year ROI
  - 5-year customer worth $700; could prices reach $350?

Conclusion #2

Maybe CGN is okay for some people?

- IPv6 is coming RSN
- Web and email work fine through CGN
- How do you know who would be okay with CGN?
  - DPI
  - Customer self-selection

How will prices be affected?

- CGN costs $30 per year more than old-fashioned Internet access
- Native IPv4 costs $11-70 more than old-fashioned Internet access
- But wait—commercial companies don’t sell anything at cost

Conclusion #3

Price before scarcity	Basic Internet (CGN)	Advanced Internet (status quo)
$33/month $400/year	$37.83/month $441/year	$40.88/month Up to $495/year
	+10%	+21%

Prices will increase or margins will decrease

Margin before scarcity	Margin on CGN	Margin on Bought IPv4
$140 on $400 ARPU 35%	$110 on $400 ARPU 27%	$70 on $400 ARPU 17.5%

How far can we take this thought experiment?

- When will ISPs offer an IPv6-only service?
  - For price-sensitive customers or to protect profit
- Will content and electronics be ready in time?
  - See Game Theory of IPv4-IPv6 Transition

Conclusion #4

- One $contract_term after IPv4 runout, everyone will have IPv6.
- With ARIN and LACNIC run out mid-2014, the prudent ISP will make sure all of their customers and services are running IPv6 by the end of 2014.

Conclusions

1. CGN costs $1.5 million over five years for every 10,000 users it's used for, or $30 per user per year.

2. 

3.

Price before scarcity	Basic Internet (CGN)	Advanced Internet (status quo)
$33/month $400/year	$37.83/month $441/year	$40.88/month Up to $495/year

4. The rational network will have 100% IPv6 by end of 2014.

Draw your own conclusions

Slides, spreadsheet, and paper available at http://www.asgard.org

Conclusion?

Draw your own conclusions!

Slides, spreadsheet, and paper available at http://www.asgard.org

Introduction

- What will it cost to use CGN?
  - Based on RMv6TF 2012 talk “TCO of CGN”
- What will it cost to run dual-stack?
  - Based on NANOG 57 talk
- What will it cost to buy IPv4 addresses?
  - New material

What will it cost to run dual stack?

Cost of Dual-Stack

- Asked experts on various industry segments
  - Data Center/Host/Content
  - ISP
  - Enterprise
- Deployment Cost
- Operational Cost

Deployment Costs

Data Center, Hosting, Content	Security appliances, Monitoring systems	$1 per user
	Application development	$6 per user
ISP	Training 2-3 hours of training	$0.15 per user $150 per support/NOC employee 1 support staff per 1000 subs
	CPE	$25 per user $50 each, but only half need upgrades
Consumer Electronics	Labor	$0.30 per device

Capital expenditures are reduced if spread over a longer period of time, when upgrades were planned anyway.
So, start four years ago and it's cheap.

Operations Costs

	Develop	Operate
Content Data Center, Hosting,	$6 *pupy* +10-30% Application development Lower for hosting	$0.08 *pupy* 20% of OpEx increases by 1-5%
ISP	$6.40 *pupy* Device code	$0.25 - $1.27 *pupy*
Consumer Electronics	$0	$0

pupy = “Per User Per Year”

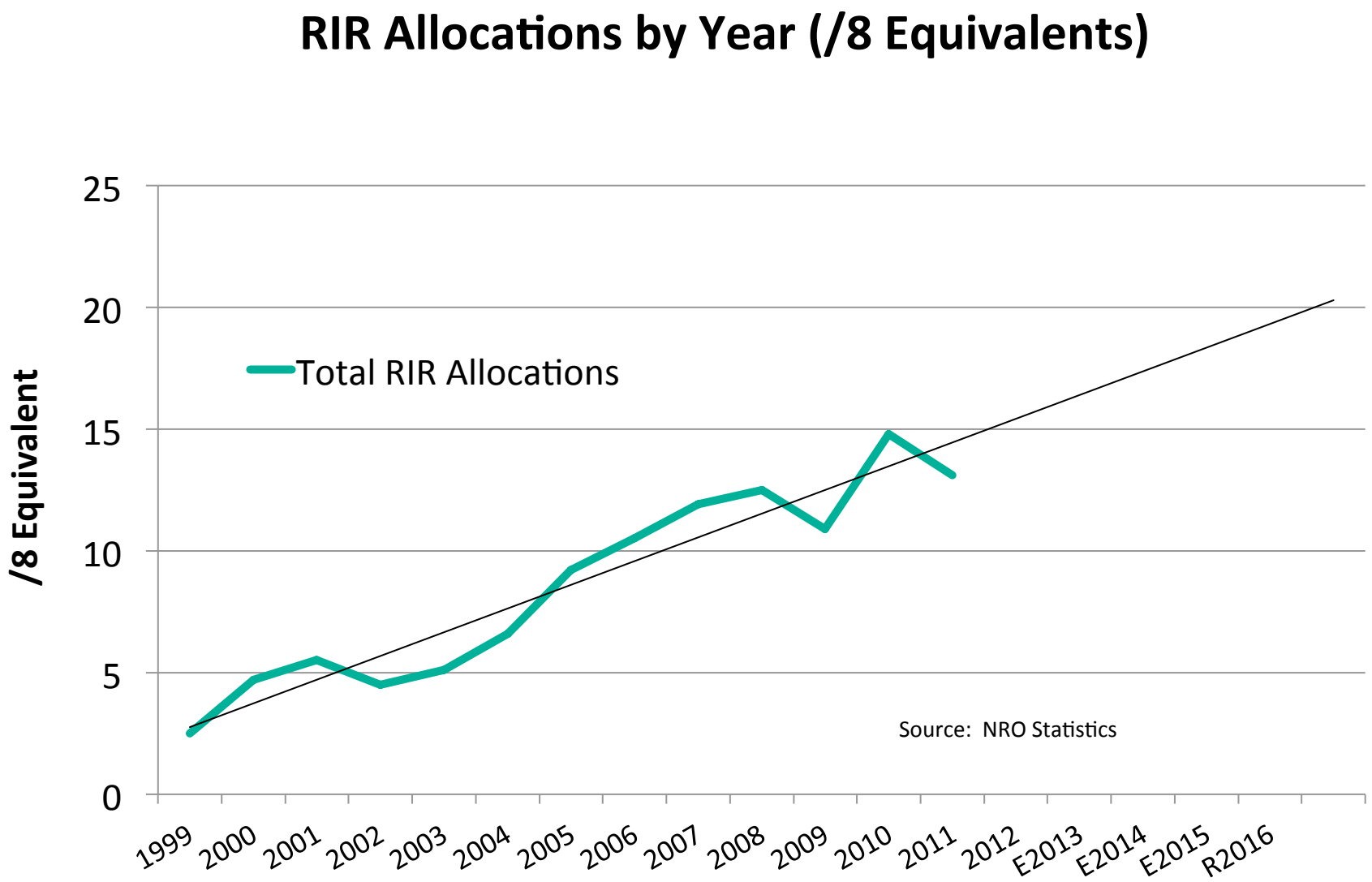
What will it cost to run dual-stack?

	Deploy	Operate
Data center Hosting Content	$7 per user	$6.08 per user per year
ISP	$25 per user	$7.50 per user per year
Electronics	$0.30 per device	$0 per device

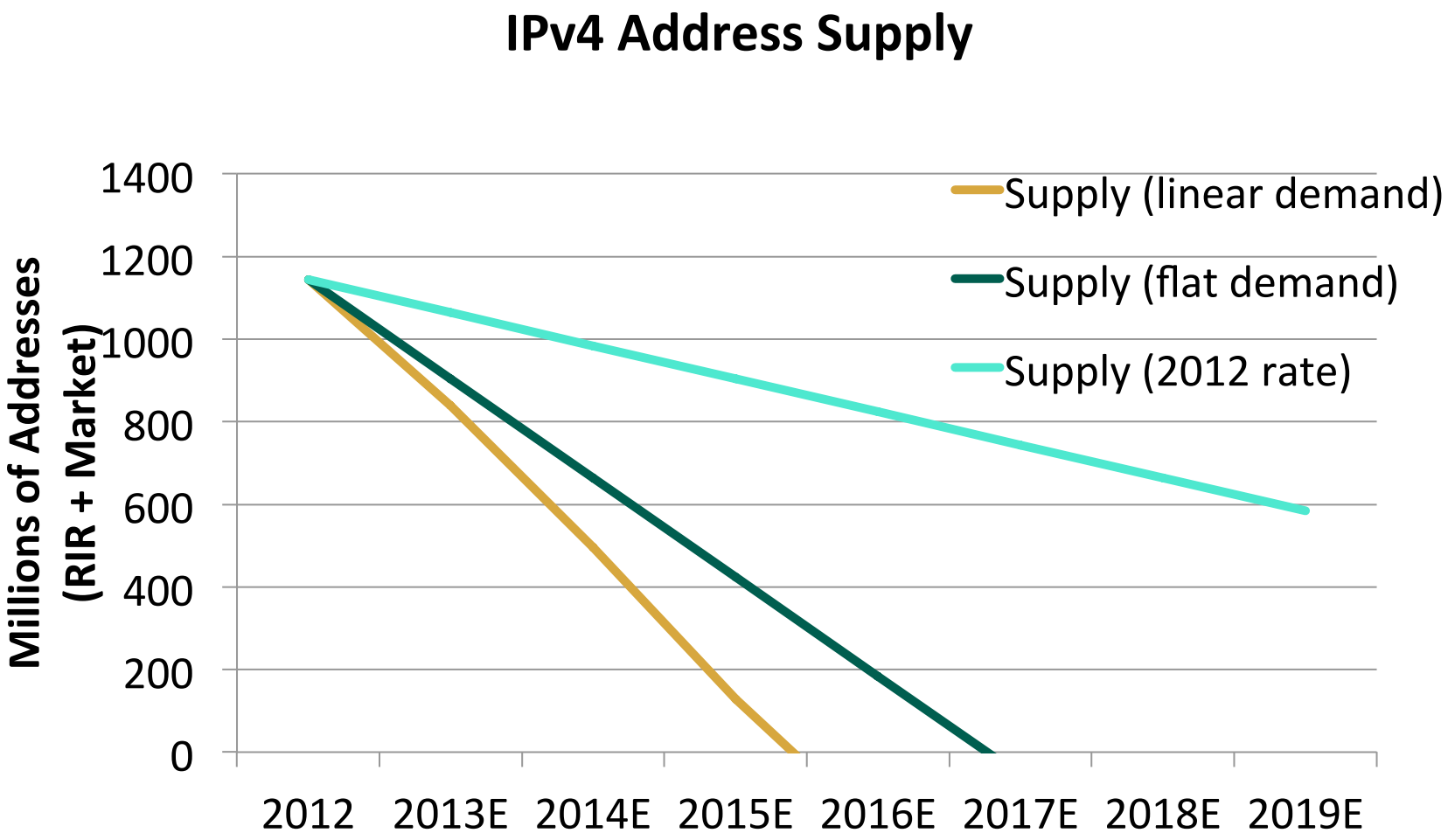
- Costs listed err to the high end
- Reduce deployment cost by starting sooner
- Reduce operation cost by limiting time dual-stack is supported

What will it cost to buy IPv4 addresses?

IPv4 Demand


RIR Allocations by Year (/8 Equivalents)
/8 Equivalent
25
20
15
10
5
0
Total RIR Allocations
Source: NRO Statistics
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
E2013
E2014
E2015
R2016

IPv4 Supply


IPv4 Address Supply
Millions of Addresses (RIR + Market)
1400
1200
1000
800
600
400
200
0
2012
2013E
2014E
2015E
2016E
2017E
2018E
2019E
Supply (linear demand)
Supply (flat demand)
Supply (2012 rate)

IPv4 Supply

At what price would someone sell an IPv4 address?

Tier	Summary	Cost per Address[1]	Addresses Available[2]
Tier 0	Remaining RIR space	$0.03 - $4	144,000,000
Tier 1	Unused	$9 - 12	480,000,000
Tier 2	Underutilized	$10 - 16	520,000,000
Tier 3	Substitutable	>$100	All IPv4

[1] "Cost" is not the same as "Price."

[2] Source: ARIN, LACNIC, AfriNIC; RouteViews

What will it cost to buy IPv4 addresses?

	2014	2015	2016	2017
Demand	280M	310M	330M	350M
Supply (Abandoned)	410M	100M	0	0
Supply (Underutilized)	520M	520M	290M	0
Cost[1]	$9 - 12	$9 - 16	$16-20	$n

[1] "Cost" is not the same as "Price."

- ***Expectation*** of price is not reflected; may be much higher.
- How many IPv4 addresses might be made available by substituting CGN (at US$30 or more)?

Resolution

Q: What will it cost to use CGN?
A: $30 per new user per year

Q: What will it cost to run dual-stack?
A: (ISP) $7.50 *pupy*
A: (Content) $6 *pupy*

Q: What will it cost to buy IPv4 addresses?
A: *At least* $9-20 per new user per year until 2017.

Q: How can I reduce my costs?

DISCUSSION