



IPアドレスの行方



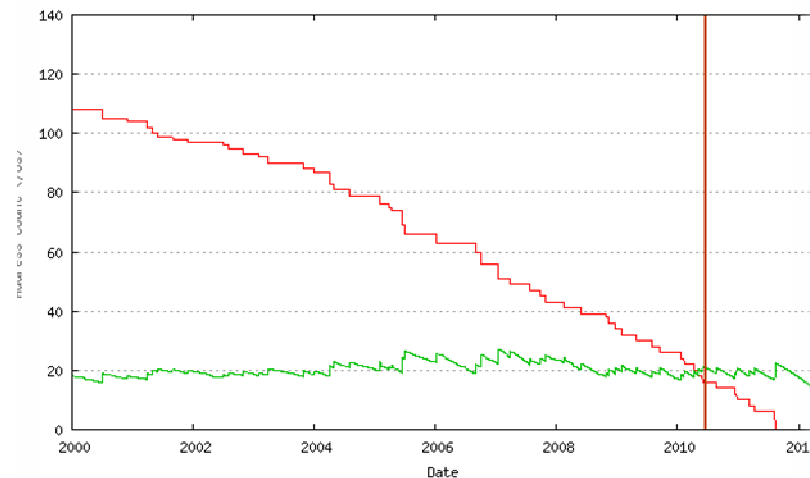
<http://designgarden.jp/beertobeer/>

Shishio Tsuchiya

shtsuchi@cisco.com

IPv4アドレスは本当になくなるのか？

- APNICのGeoff HustonはIPv4アドレスの枯渇予想によると、IANAのプールが無くなるのが**2011年**8月、各RIRのIPアドレスが無くなるのが、2012年4月
- 現時点でのIANAのクラスAアドレス/8は**16**個、そのうち残り5個になった時点で、各RIR(ARIN, RIPENCC, APNIC, LACNIC, AfriNIC)に自動的に割り当てられる



IPv4 Address Fractal Map 2000年1月

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003 GE	002 Reserved	013 Xerox	012 AT&T	017 Apple	018 MIT	023 Reserved	022 US DoD	233 Multicast	232 Multicast	237 Multicast	238 Multicast	243 Class E	242 Class E	253 Class E	252 Class E
004 L3	007 ARIN	008 L3	011 US DoD	030 US DoD	029 US DoD	024 Cable	025 UK Defense	230 Multicast	231 Multicast	226 Multicast	225 Multicast	244 Class E	247 Class E	248 Class E	251 Class E
005 Reserved	006 US DoD	009 IBM	010 Private	031 Reserved	028 US DoD	027 Reserved	026 US DoD	229 Multicast	228 Multicast	227 Multicast	224 Multicast	245 Class E	246 Class E	249 Class E	250 Class E
058 APnic	057 SITA	054 Merck	053 Cap Debis	032 AT&T	035 MERIT	036 Reserved	037 Reserved	218 APnic	219 APnic	220 APnic	223 Reserved	202 APnic	201 LACnic	198 Various	197 Reserved
059 APnic	056 US Postal	055 US DoD	052 El duPONT	033 US DoD	034 Haliburton	039 Reserved	038 PSI	217 RIPE	216 ARIN	221 APnic	222 APnic	203 APnic	200 LACnic	199 ARIN	196 AFRnic
060 APnic	061 APnic	050 Reserved	051 UK DSS	046 Reserved	045 Interop	040 Eli Lily	041 AFRnic	214 US DoD	215 US DoD	210 APnic	209 ARIN	204 ARIN	205 ARIN	194 RIPE	195 RIPE
063 ARIN	062 RIPE	049 Reserved	048 Prudential	047 Bell North	044 Radio	043 Inet	042 Reserved	213 RIPE	212 RIPE	211 APnic	208 ARIN	207 ARIN	206 ARIN	192 RIPE	192 Various
064 ARIN	067 ARIN	068 ARIN	069 ARIN	122 APnic	123 APnic	124 APnic	127 Loopback	128 Various	131 Various	132 Various	133 Various	186 LACnic	187 LACnic	188 Various	191 Various
065 ARIN	066 ARIN	071 ARIN	070 ARIN	121 APnic	120 APnic	125 APnic	126 APnic	129 Various	130 Various	135 Various	134 Various	185 Reserved	184 Reserved	189 LACnic	190 LACnic
078 RIPE	077 RIPE	072 ARIN	073 ARIN	118 APnic	119 APnic	114 APnic	113 Reserved	142 Various	141 Various	136 Various	137 Various	182 Reserved	183 Reserved	178 Reserved	177 Reserved
079 RIPE	076 ARIN	075 ARIN	074 ARIN	117 APnic	116 APnic	115 APnic	112 Reserved	143 Various	140 Various	139 Various	138 Various	181 Reserved	180 Reserved	179 Reserved	176 Reserved
080 RIPE	081 RIPE	094 RIPE	095 RIPE	096 ARIN	097 ARIN	110 Reserved	111 Reserved	144 Various	145 Various	158 Various	159 Various	160 Various	161 Various	174 Reserved	175 Reserved
083 RIPE	082 RIPE	093 RIPE	092 RIPE	099 ARIN	098 ARIN	109 Reserved	108 Reserved	147 Various	146 Various	157 Various	156 Various	163 Various	162 Various	173 Reserved	172 Various
084 RIPE	087 RIPE	088 RIPE	091 RIPE	100 Reserved	103 Reserved	104 Reserved	107 Reserved	148 Various	151 Various	152 Various	155 Various	164 Various	167 Various	168 Various	171 Various
085 RIPE	086 RIPE	089 RIPE	090 RIPE	101 Reserved	102 Reserved	105 Reserved	106 Reserved	149 Various	150 Various	153 Various	154 Various	165 Various	166 Various	169 Various	170 Various

Fractal map: Layout by Randall Munroe, Time Sequence by Tony Hain, Highlighted by Jeff Apcar

IPv4 Address Fractal Map 2009年1月

000 Reserved	001 Reserved	014 Reserved	015 HP	016 DEC	019 Ford	020 CsC	021 US DoD	234 Multicast	235 Multicast	236 Multicast	239 Multicast	240 Class E	241 Class E	254 Class E	255 Class E
003 GE	002 Reserved	013 Xerox	012 AT&T	017 Apple	018 MIT	023 Reserved	022 US DoD	233 Multicast	232 Multicast	237 Multicast	238 Multicast	243 Class E	242 Class E	253 Class E	252 Class E
004 L3	007 ARIN	008 L3	011 US DoD	030 US DoD	029 US DoD	024 Cable	025 UK Defense	230 Multicast	231 Multicast	226 Multicast	225 Multicast	244 Class E	247 Class E	248 Class E	251 Class E
005 Reserved	006 US DoD	009 IBM	010 Private	031 Reserved	028 US DoD	027 Reserved	026 US DoD	229 Multicast	228 Multicast	227 Multicast	224 Multicast	245 Class E	246 Class E	249 Class E	250 Class E
058 APnic	057 SITA	054 Merck	053 Cap Debis	032 AT&T	035 MERIT	036 Reserved	037 Reserved	218 APnic	219 APnic	220 APnic	223 Reserved	202 APnic	201 LACnic	198 Various	197 AFRINic
059 APnic	056 US Postal	055 US DoD	052 El duPONT	033 US DoD	034 Haliburton	039 Reserved	038 PSI	217 RIPE	216 ARIN	221 APnic	222 APnic	203 APnic	200 LACnic	199 ARIN	196 AFRnic
060 APnic	061 APnic	050 Reserved	051 UK DSS	046 Reserved	045 Interop	040 Eli Lily	041 AFRNIC	214 US DoD	215 US DoD	210 APnic	209 ARIN	204 ARIN	205 ARIN	194 RIPE	195 RIPE
063 ARIN	062 RIPE	049 Reserved	048 Prudential	047 Bell North	044 Radio	043 Inet	042 Reserved	213 RIPE	212 RIPE	211 APnic	208 ARIN	207 ARIN	206 ARIN	192 RIPE	192 Various
064 ARIN	067 ARIN	068 ARIN	069 ARIN	122 APnic	123 APnic	124 APnic	127 Loopback	128 Various	131 Various	132 Various	133 Various	186 LACnic	187 LACnic	188 Various	191 Various
065 ARIN	066 ARIN	071 ARIN	070 ARIN	121 APnic	120 APnic	125 APnic	126 APnic	129 Various	130 Various	135 Various	134 Various	185 Reserved	184 ARIN	189 LACnic	190 LACnic
078 RIPE	077 RIPE	072 ARIN	073 ARIN	118 APnic	119 APnic	114 APnic	113 APnic	142 Various	141 Various	136 Various	137 Various	182 Reserved	183 Reserved	178 Reserved	177 Reserved
079 RIPE	076 ARIN	075 ARIN	074 ARIN	117 APnic	116 APnic	115 APnic	112 APnic	143 Various	140 Various	139 Various	138 Various	181 Reserved	180 Reserved	179 Reserved	176 Reserved
080 RIPE	081 RIPE	094 RIPE	095 RIPE	096 ARIN	097 ARIN	110 APnic	111 APnic	144 Various	145 Various	158 Various	159 Various	160 Various	161 Various	174 ARIN	175 Reserved
083 RIPE	082 RIPE	093 RIPE	092 RIPE	099 ARIN	098 ARIN	109 Reserved	108 ARIN	147 Various	146 Various	157 Various	156 Various	163 Various	162 Various	173 ARIN	172 Various
084 RIPE	087 RIPE	088 RIPE	091 RIPE	100 Reserved	103 Reserved	104 Reserved	107 Reserved	148 Various	151 Various	152 Various	155 Various	164 Various	167 Various	168 Various	171 Various
085 RIPE	086 RIPE	089 RIPE	090 RIPE	101 Reserved	102 Reserved	105 Reserved	106 Reserved	149 Various	150 Various	153 Various	154 Various	165 Various	166 Various	169 Various	170 Various

Fractal map. Layout by Randall Munroe. Time Sequence by Tony Hain. Highlighted by Jeff Apcar

IPv4 Address Fractal Map 2010年1月 JANOG25前

000 Reserved	001 Reserved	014 Reserved	015 HP	016 DEC	019 Ford	020 CsC	021 US DoD	234 Multicast	235 Multicast	236 Multicast	239 Multicast	240 Class E	241 Class E	254 Class E	255 Class E
003 GE	002 RIPE	013 Xerox	012 AT&T	017 Apple	018 MIT	023 Reserved	022 US DoD	233 Multicast	232 Multicast	237 Multicast	238 Multicast	243 Class E	242 Class E	253 Class E	252 Class E
004 L3	007 ARIN	008 L3	011 US DoD	030 US DoD	029 US DoD	024 Cable	025 UK Defense	230 Multicast	231 Multicast	226 Multicast	225 Multicast	244 Class E	247 Class E	248 Class E	251 Class E
005 Reserved	006 US DoD	009 IBM	010 Private	031 Reserved	028 US DoD	027 Reserved	026 US DoD	229 Multicast	228 Multicast	227 Multicast	224 Multicast	245 Class E	246 Class E	249 Class E	250 Class E
058 APnic	057 SITA	054 Merck	053 Cap Debis	032 AT&T	035 MERIT	036 Reserved	037 Reserved	218 APnic	219 APnic	220 APnic	223 Reserved	202 APnic	201 LACnic	198 Various	197 AFRINic
059 APnic	056 US Postal	055 US DoD	052 El duPONT	033 US DoD	034 Haliburton	039 Reserved	038 PSI	217 RIPE	216 ARIN	221 APnic	222 APnic	203 APnic	200 LACnic	199 ARIN	196 AFRnic
060 APnic	061 APnic	050 Reserved	051 UK DSS	046 RIPE	045 Interop	040 Eli Lily	041 AFRNIC	214 US DoD	215 US DoD	210 APnic	209 ARIN	204 ARIN	205 ARIN	194 RIPE	195 RIPE
063 ARIN	062 RIPE	049 Reserved	048 Prudential	047 Bell North	044 Radio	043 Inet	042 Reserved	213 RIPE	212 RIPE	211 APnic	208 ARIN	207 ARIN	206 ARIN	192 RIPE	192 Various
064 ARIN	067 ARIN	068 ARIN	069 ARIN	122 APnic	123 APnic	124 APnic	127 Loopback	128 Various	131 Various	132 Various	133 Various	186 LACnic	187 LACnic	188 Various	191 Various
065 ARIN	066 ARIN	071 ARIN	070 ARIN	121 APnic	120 APnic	125 APnic	126 APnic	129 Various	130 Various	135 Various	134 Various	185 Reserved	184 ARIN	189 LACnic	190 LACnic
078 RIPE	077 RIPE	072 ARIN	073 ARIN	118 APnic	119 APnic	114 APnic	113 APnic	142 Various	141 Various	136 Various	137 Various	182 APNIC	183 APNIC	178 RIPE	177 Reserved
079 RIPE	076 ARIN	075 ARIN	074 ARIN	117 APnic	116 APnic	115 APnic	112 APnic	143 Various	140 Various	139 Various	138 Various	181 Reserved	180 APNIC	179 Reserved	176 Reserved
080 RIPE	081 RIPE	094 RIPE	095 RIPE	096 ARIN	097 ARIN	110 APnic	111 APnic	144 Various	145 Various	158 Various	159 Various	160 Various	161 Various	174 ARIN	175 APNIC
083 RIPE	082 RIPE	093 RIPE	092 RIPE	099 ARIN	098 ARIN	109 RIPE	108 ARIN	147 Various	146 Various	157 Various	156 Various	163 Various	162 Various	173 ARIN	172 Various
084 RIPE	087 RIPE	088 RIPE	091 RIPE	100 Reserved	103 Reserved	104 Reserved	107 Reserved	148 Various	151 Various	152 Various	155 Various	164 Various	167 Various	168 Various	171 Various
085 RIPE	086 RIPE	089 RIPE	090 RIPE	101 Reserved	102 Reserved	105 Reserved	106 Reserved	149 Various	150 Various	153 Various	154 Various	165 Various	166 Various	169 Various	170 Various

Fractal map: Layout by Randall Munroe, Time Sequence by Tony Hain, Highlighted by Jeff Apcar

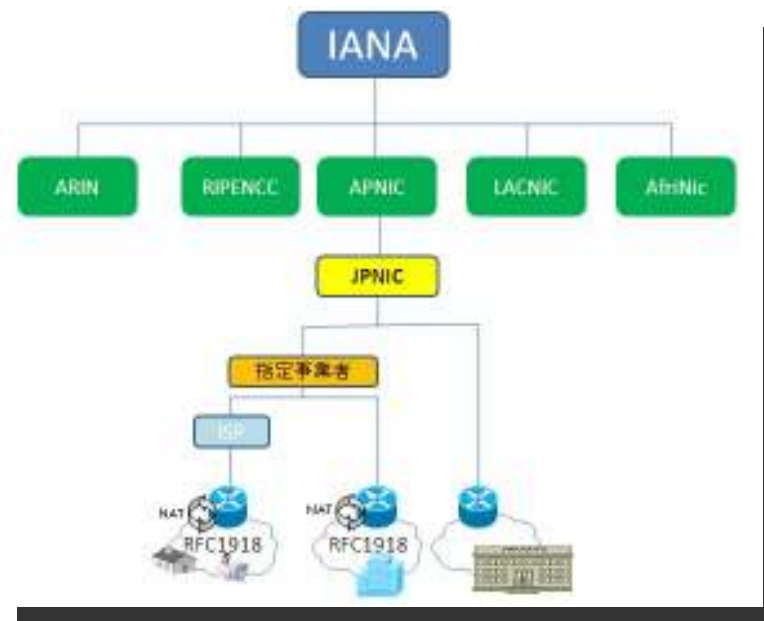
IPv4 Address Fractal Map 2010年7月

000 Reserved	001 APNIC	014 APNIC	015 HP	016 DEC	019 Ford	020 CsC	021 US DoD	234 Multicast	235 Multicast	236 Multicast	239 Multicast	240 Class E	241 Class E	254 Class E	255 Class E
003 GE	002 RIPE	013 Xerox	012 AT&T	017 Apple	018 MIT	023 Reserved	022 US DoD	233 Multicast	232 Multicast	237 Multicast	238 Multicast	243 Class E	242 Class E	253 Class E	252 Class E
004 L3	007 ARIN	008 L3	011 US DoD	030 US DoD	029 US DoD	024 Cable	025 UK Defense	230 Multicast	231 Multicast	226 Multicast	225 Multicast	244 Class E	247 Class E	248 Class E	251 Class E
005 Reserved	006 US DoD	009 IBM	010 Private	031 RIPE	028 US DoD	027 APNIC	026 US DoD	229 Multicast	228 Multicast	227 Multicast	224 Multicast	245 Class E	246 Class E	249 Class E	250 Class E
058 APnic	057 SITA	054 Merck	053 Cap Debis	032 AT&T	035 MERIT	036 Reserved	037 Reserved	218 APnic	219 APnic	220 APnic	223 APNIC	202 APnic	201 LACnic	198 Various	197 AFRINic
059 APnic	056 US Postal	055 US DoD	052 El duPONT	033 US DoD	034 Haliburton	039 Reserved	038 PSI	217 RIPE	216 ARIN	221 APnic	222 APnic	203 APnic	200 LACnic	199 ARIN	196 AFRnic
060 APnic	061 APnic	050 ARIN	051 UK DSS	046 RIPE	045 Interop	040 Eli Lily	041 AFRNIC	214 US DoD	215 US DoD	210 APnic	209 ARIN	204 ARIN	205 ARIN	194 RIPE	195 RIPE
063 ARIN	062 RIPE	049 Reserved	048 Prudential	047 Bell North	044 Radio	043 Inet	042 Reserved	213 RIPE	212 RIPE	211 APnic	208 ARIN	207 ARIN	206 ARIN	192 RIPE	192 Various
064 ARIN	067 ARIN	068 ARIN	069 ARIN	122 APnic	123 APnic	124 APnic	127 Loopback	128 Various	131 Various	132 Various	133 Various	186 LACnic	187 LACnic	188 Various	191 Various
065 ARIN	066 ARIN	071 ARIN	070 ARIN	121 APnic	120 APnic	125 APnic	126 APnic	129 Various	130 Various	135 Various	134 Various	185 Reserved	184 ARIN	189 LACnic	190 LACnic
078 RIPE	077 RIPE	072 ARIN	073 ARIN	118 APnic	119 APnic	114 APnic	113 APnic	142 Various	141 Various	136 Various	137 Various	182 APNIC	183 APNIC	178 RIPE	177 Reserved
079 RIPE	076 ARIN	075 ARIN	074 ARIN	117 APnic	116 APnic	115 APnic	112 APnic	143 Various	140 Various	139 Various	138 Various	181 LACnic	180 APNIC	179 Reserved	176 RIPE
080 RIPE	081 RIPE	094 RIPE	095 RIPE	096 ARIN	097 ARIN	110 APnic	111 APnic	144 Various	145 Various	158 Various	159 Various	160 Various	161 Various	174 ARIN	175 APNIC
083 RIPE	082 RIPE	093 RIPE	092 RIPE	099 ARIN	098 ARIN	109 RIPE	108 ARIN	147 Various	146 Various	157 Various	156 Various	163 Various	162 Various	173 ARIN	172 Various
084 RIPE	087 RIPE	088 RIPE	091 RIPE	100 Reserved	103 Reserved	104 Reserved	107 ARIN	148 Various	151 Various	152 Various	155 Various	164 Various	167 Various	168 Various	171 Various
085 RIPE	086 RIPE	089 RIPE	090 RIPE	101 Reserved	102 Reserved	105 Reserved	106 Reserved	149 Various	150 Various	153 Various	154 Various	165 Various	166 Various	169 Various	170 Various

Fractal map: Layout by Randall Munroe, Time Sequence by Tony Hain, Highlighted by Jeff Apcar

IPアドレスはどの様に私たちの元に届くのか？

- IANA→RIR(APNIC)→NIR(JPNIC)と割り振られる
- RIRではその**IPアドレスの妥当性を評価**し、NIRに割り振る
- ユーザ宅内、企業内では**RFC1918アドレス**が使用され、NATを利用して、インターネットへ接続を行う。

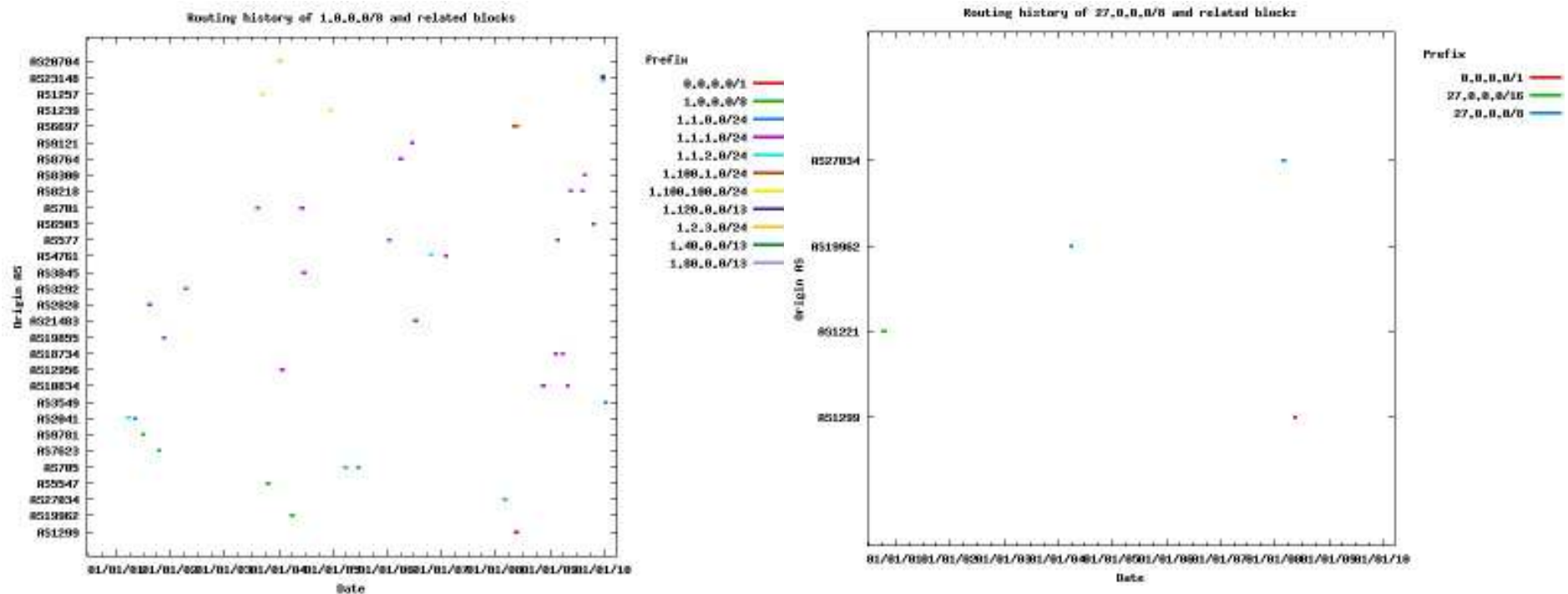


1.0.0.0/8

- 2010年1月にAPNICに1/8および27/8が割り振られた
- 1.0.0.0/8は下記の様な問題を含むと考えられている。
 - ✓アサインされる前にBGPアナウンスが行われている
 - ✓RFC1918的に使用されている



ほんとに勝手にアナウンスされてるの？



- 同時APNICにアサインされた27/8との比較してもかなり頻繁にアナウンスされてるのがわかる
- 期間は2000-01-25 to 2010-01-25

<http://albatross.ripe.net/cgi-bin/rex.pl>

プライベートアドレスとして使われている例

- anoNet <http://anonet.org/>

OpenVPNでVPNセッションを張って、QuaggaでBGPでルート交換を行う。

内部ネットワーク用に1/8を使用している

DNS:1.234.56.4, 1.10.11.1, 1.0.12.2

IRC:1.1.1.1, 1.234.56.2

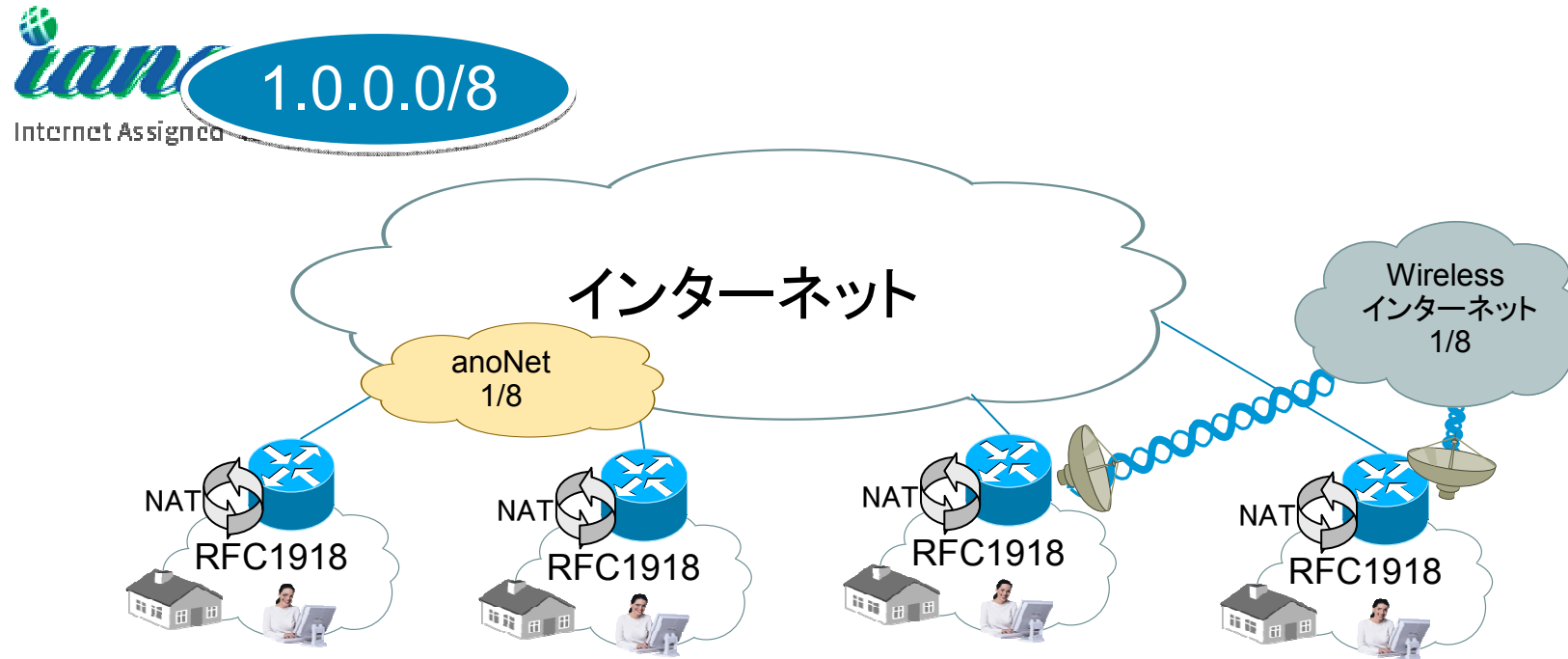
そしてIPv6へ! アドレスはde00::/8!! IRCはdead:beef::1

- WIANA(Wireless Internet Assigned Numbers Authority) <http://global.wiana.org/>

“Wired”インターネットとは別のWirelessインターネットを構築。

各ノードに対して1/8を使用している

anoNet & WIANA Problem



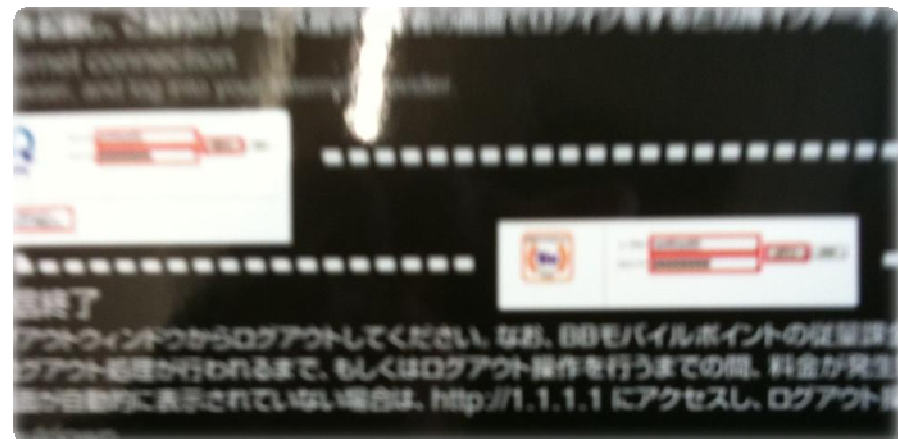
- インターネットとは別ネットワークを構築した時に RFC1918との競合を防ぐために使用するケースが多い

街で見かけた1.1.1.1



某ホテル

某特急電車



すべて

"http://1.1.1.1"

約 1,110 件 (0.11 秒)

日本語のページを検索

某検索エンジン

なぜ1/8だけこんなに問題が多いのか？

- BGPのアナウンス

ミスオペレーションなどが問題？

1.1.1.1をルータIDなどに使用？=>マニュアルの問題？

- 内部アドレスとしての使用

テストネットワークの存在

検索結果にはオペレーションマニュアル以外にもメーカーのマニュアルも多数

中には工場出荷時のアドレスとして設定してる機器もあるみたい。

RFC5737

IPv4 Address Blocks Reserved for Documentation

- ドキュメンテーションの為のinformational RFC

- history

- July 1990 [RFC1166 INTERNET NUMBERS](#)

- 192.0.2.0/24 TESTに使用

- June 2009 [draft-iana-ipv4-examples-00](#)

- [RFC3849](#),[RFC2606](#) などの様にIPv4でも文章アドレスが必要との提案

- 192.0.2.0/24 (TEST-NET-1)に加え、198.51.100.0/24(TEST-NET-2)

- 203.0.113.0/24(TEST-NET-3)を予約

- これら3つのネットワークはパブリックインターネットには出ないので、パケットフィルタに加えるべき(SHOULD)

- 128.66.0.0/16が同じ目的でかつて使用されていた。しかし[RFC5735](#)での記載は無い為、こちらは通常アドレスとして使用される

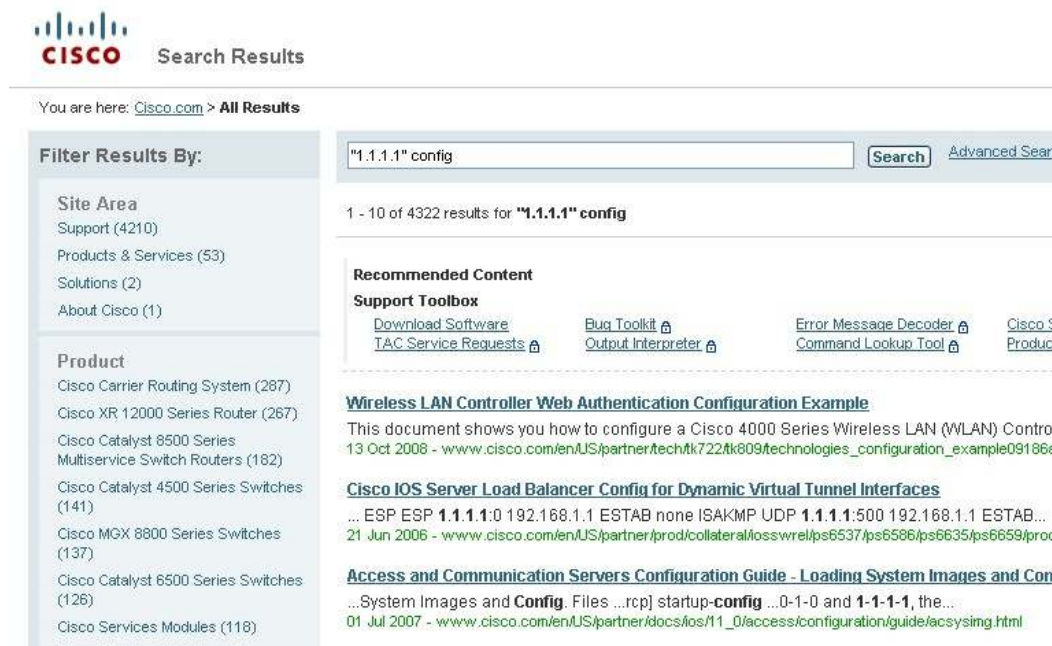
- Jan 2010 [RFC5737](#)

ドキュメンテーションの為のガイドライン

用途	例	リファレンス
IPv4アドレス (グローバル)	192.0.2.0/24 (TEST-NET-1) 198.51.100.0/24(TEST-NET-2) 203.0.113.0/24(TEST-NET-3)	RFC5737
IPv4アドレス (プライベート)	10.0.0.0/8 172.16.0.0/12 192.168.0.0/16	RFC1918
IPv6アドレス	2001:db8::/32	RFC3849
DNS Name	.example example.com example.net example.org	RFC2606
JPDメイン	EXAMPLE.JP EXAMPLE1.JP ドメイン名例.JP	JPRS FAQ
BGP ASN(グローバル)	64496 – 64511(16bit) 65536 – 65551(32bit)	RFC5398
BGP ASN(プライベート)	64512-65534(16bit)	RFC1930

と・・・偉そうな事言ってみたけど・・・

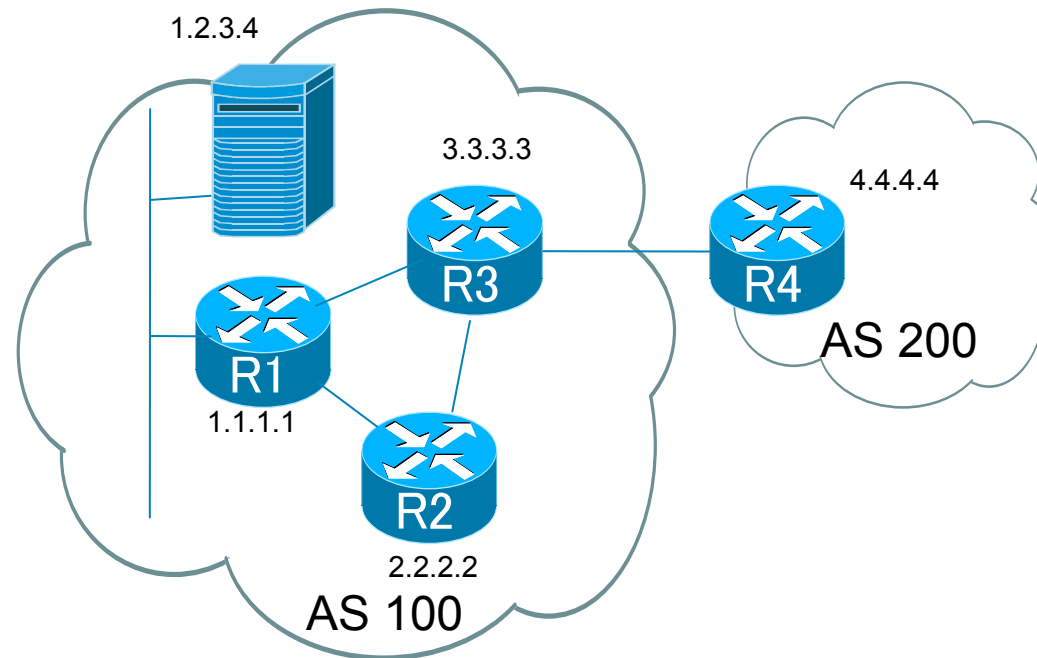
- CCOで["1.1.1.1" config]を検索すると・・・



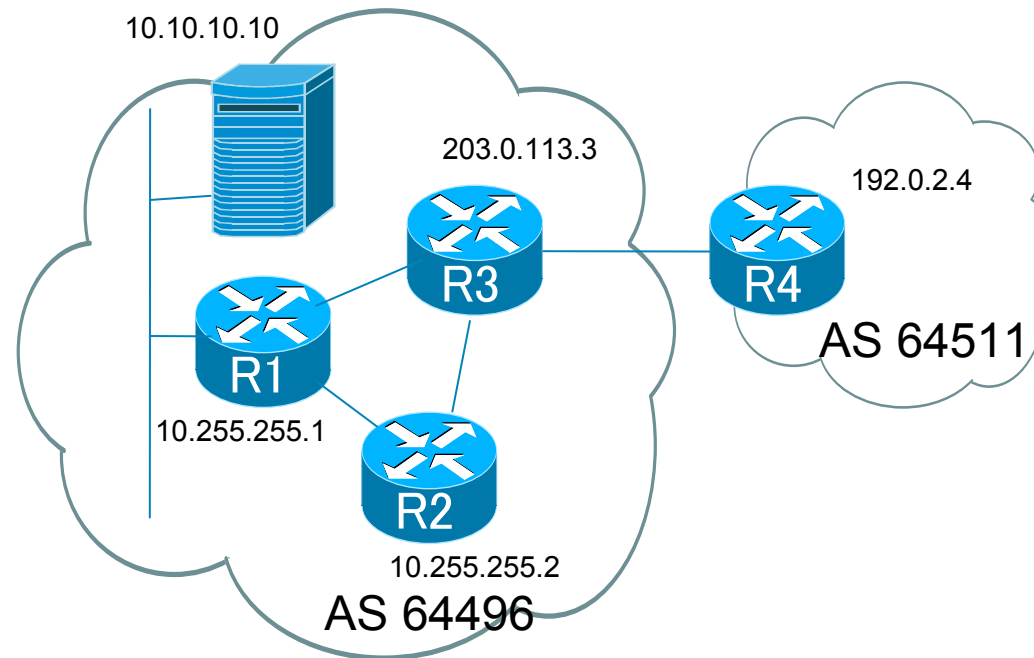
- なんと4322件。。。。
- まずIOS-XRとWLCにてDoc bugとして対応中



よくあるコンフィグサンプル



IETF Compliant Documents



- 感覚的に分かりにくいかも・・・

http://1.1.1.1は



- 気持ちはわからんでもない・・・けどね・・・

呪のアドレスを綺麗にする為の地道な努力

- 新しいプライベートアドレス(第3のネットワーク用)

色々似た考えはあるよね。これとか。

[draft-hain-1918bis](#)

[draft-shirasaki-nat444-isp-shared-addr](#)

[draft-weil-opsawg-provider-address-space](#)

- 1.1.1.1はもう特別なアドレスとしてリクエストするとか・・・
(オペレーターアドレスとか・・・)
- マニュアル(ルータID)は気をつける。

謝辞

- janog MLの下記を参考させて頂きました。皆様ありがとうございます。

[janog:09330],[janog:09334],[janog:09337]–[janog:09342]

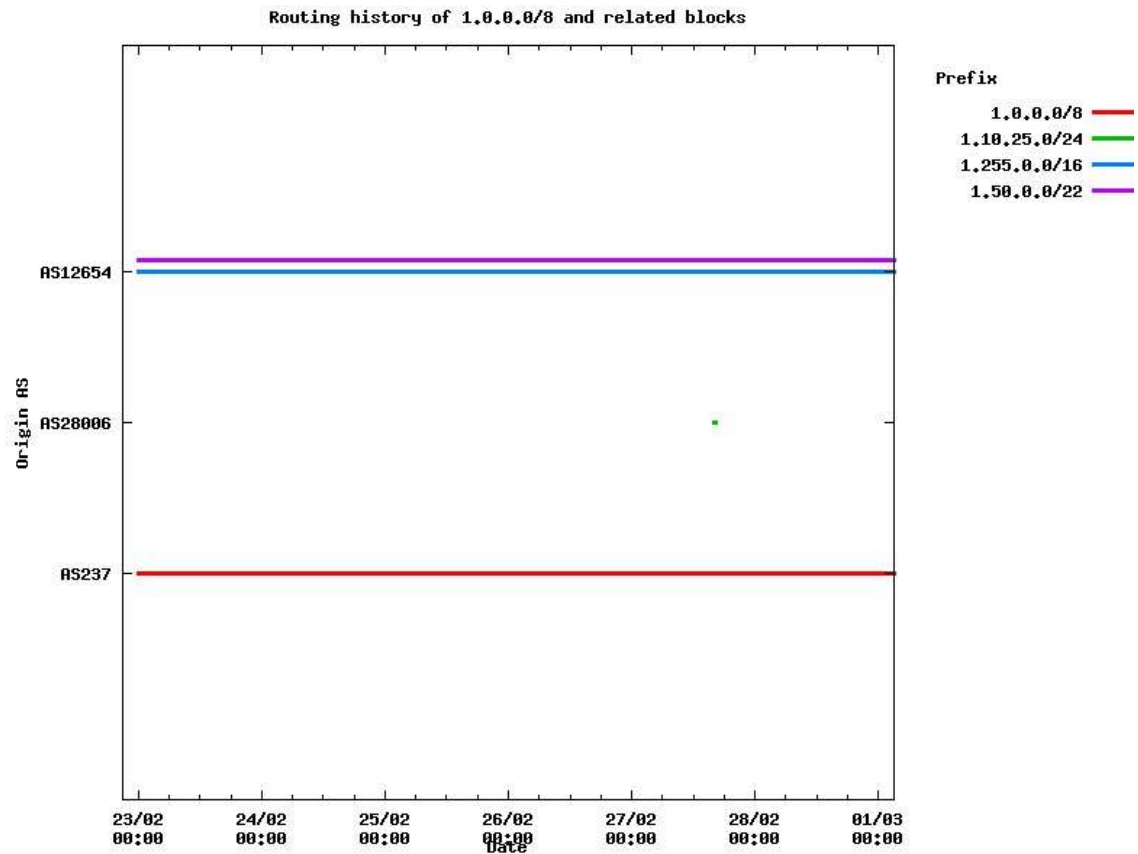
[janog:09345]–[janog:09350],[janog:09460]

- また素敵な<http://1.1.1.1>の写真を提供してくれたiTSCOM芦田さんありがとうございました。



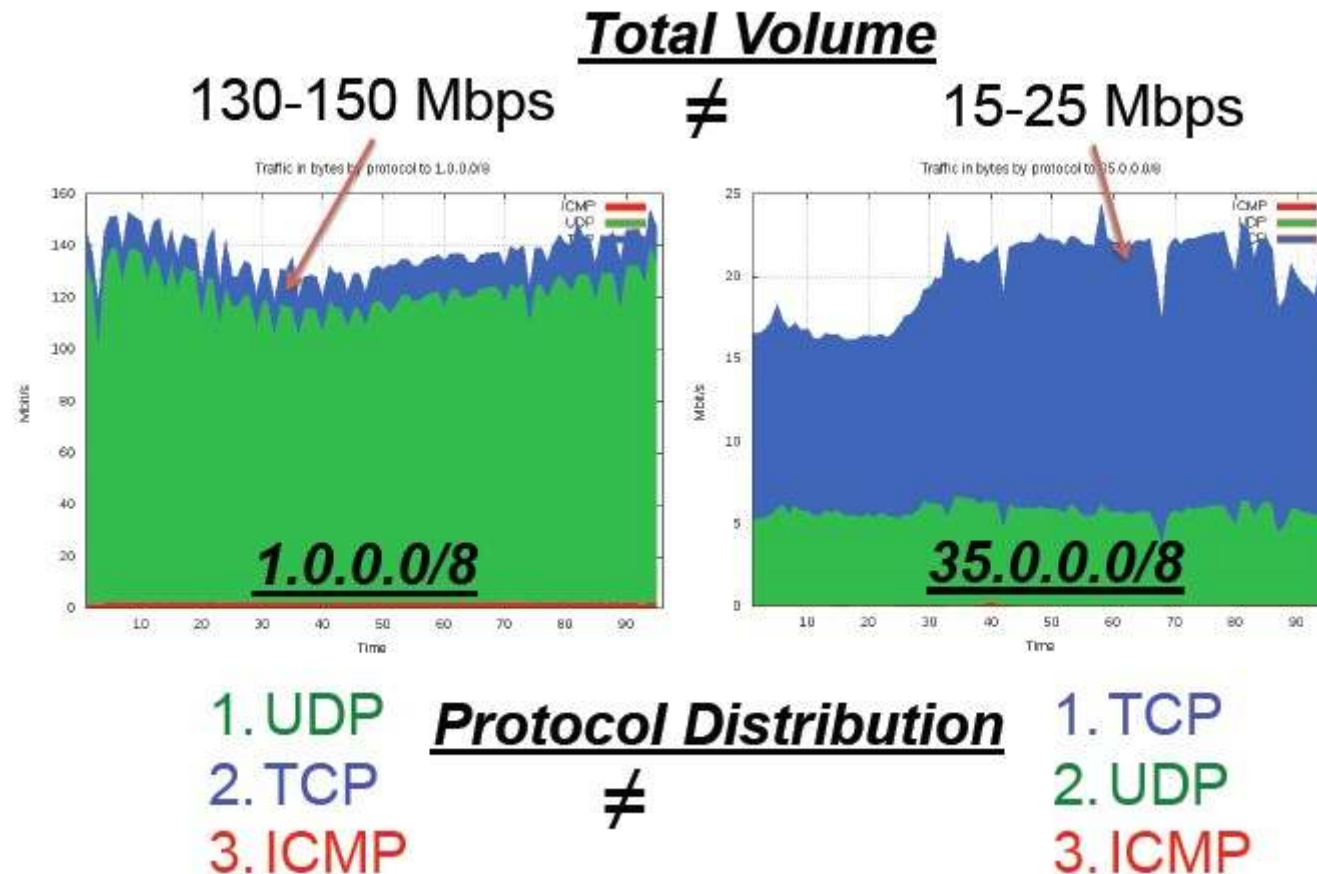
Appendix:

NANOG 1slash8



- Merit(AS237)が1/8を2010/02/23-03/01までアナウンスを行った。
- 同時に35/8もアナウンスを行い、トラフィックを比較した。

Appendix: NANOG 1slash8 *cont'd*



- 35/8と比べ、明らかに異なるトラフィック帯域およびプロトコル分布となった

Appendix: NANOG 1slash8 *cont'd*

Subnet /24	Packets	%
1.1.1.0	4797420185	44.5
1.4.0.0	1884458639	17.5
1.0.0.0	1069156477	9.9
1.2.3.0	199452209	1.8
1.1.168.0	62347104	0.5
1.10.10.0	26362000	0.2
1.0.168.0	18988771	0.1
1.1.0.0	18822018	0.1
1.0.1.0	14818941	0.1
1.2.168.0	12484394	0.1

- top10の宛先が全体の75%を占める

Appendix: NANOG 1slash8 *cont'd*

- 全体の34.5%は1.1.1.1:15206宛てのRTPパケットだった。
- 全体の17.5%は1.4.0.0 Portの33368,514,33527,3072,33493宛てのDNSトラフィックだった。
- 全体の1.8%が1.2.3.4向けのトラフィックだった。およそ10Mbps相当なIPerfトラフィックだった
- APNICは下記prefixをノーマルアロケーションより外した
1.0.0.0/24,1.1.1.0/24,1.2.3.0/24,1.4.0.0/24, 1.10.10.0/24