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360 互联网安全中心



# 从运营商视角看IPv6规模部署

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Internet Security Conference 2018 Beijing·China  
(原中国互联网安全大会)

# 如果有BGM，我想你会回来和我一起唱这首...



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听见 v4要离开  
我在某年某月 醒过来  
我想 我等 我期待  
未来却已经如此安排  
阴天 傍晚 车窗外  
未来有一v6在等待  
向左 向右 向前看  
我们要拐几个弯才到  
我遇见你 会有怎样的对白  
我等的你 还在多远的未来  
我听见风来自地铁和人海  
我排着队 拿着v6的号码牌

— 兀自乱改歌词《遇见》

# 目录

## 国际视图

我国视图

部署要求

实践情况

# CAIDA's IPv4 and IPv6 AS Core AS-level Internet Graph

[http://www.caida.org/research/topology/as\\_core\\_network/](http://www.caida.org/research/topology/as_core_network/)

## Archipelago January 2015

During a two-week period in January 2015, CAIDA researchers connected data using our distributed measurement infrastructure, Archipelago (Ark). For the IPv4 map, 116 Ark monitors in 42 countries on 6 continents probed paths toward 281 million 124 IPv4 networks. For the IPv6 map, the subset

of 47 IPv6-connected Ark monitors located in 25 countries on 6 continents concurrently probed paths toward 4.9 million IPv6 addresses. These measurements covered, correspondingly, 92.7% of the IPv4 routable prefixes and 89.3% of the globally routable IPv6 prefixes as seen in the Route Views Border Gateway Protocol (BGP) routing tables collected by Routeviews and RIPE NCC on January 1, 2015. We aggregated the captured IP-level data to construct IPv4 and IPv6

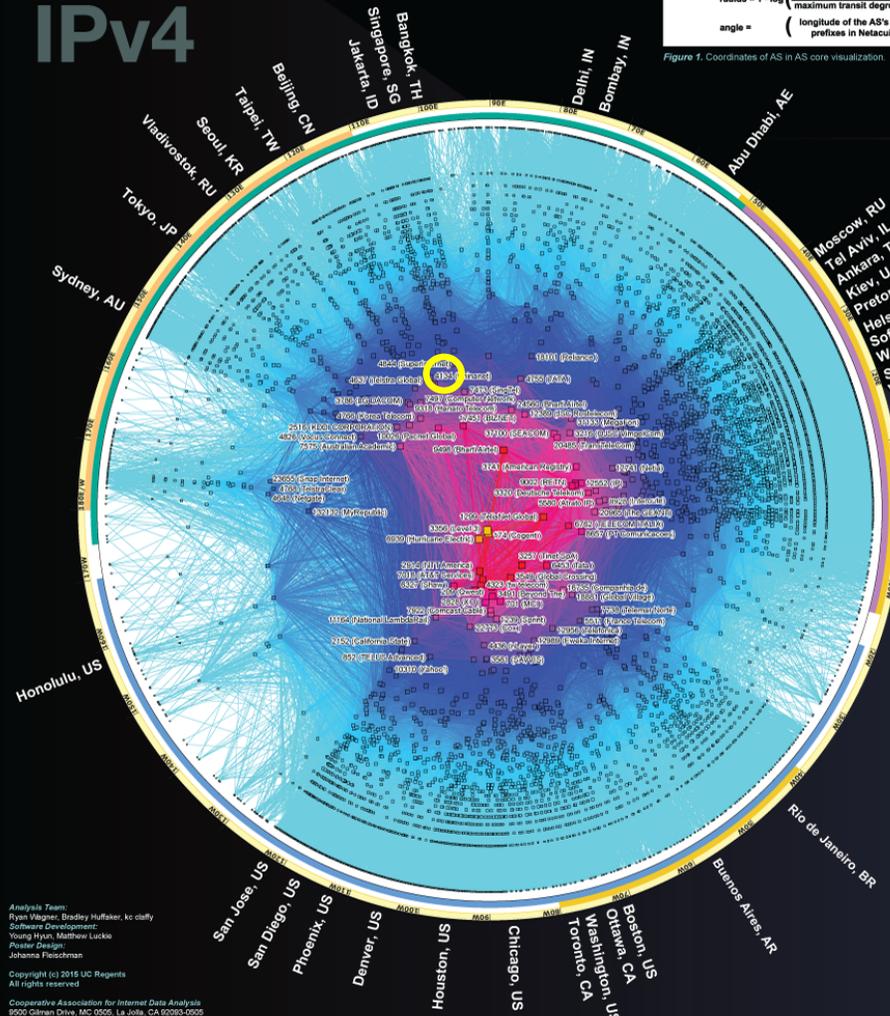
Internet connectivity graphs at the Autonomous System (AS) level. Each AS approximately corresponds to an Internet Service Provider (ISP). We map each observed IP address to the AS which announced it, i.e., to the origin (end-of-path) AS for the IP prefix representing the best match for this address in the BGP routing tables. The position of each AS node is plotted in polar coordinates (radius, angle) calculated as indicated in Figure 1.

$$\text{radius} = 1 - \log\left(\frac{\text{transit degree}(AS) + 1}{\text{maximum transit degree} + 1}\right)$$

$$\text{angle} = \left(\frac{\text{longitude of the AS's BGP prefixes in Netatlas}}{\text{Netatlas}}\right)$$

Figure 1. Coordinates of AS in AS core visualization.

# IPv4



### Analysis

As in previous years, the IPv6 graph exhibited faster relative growth than the IPv4 graph. From January 2014 to January 2015, the number of IPv6 ASes increased by 23% and the number of links connecting them increased by 29%. In the case of the IPv4 graph, the number of ASes increased by 2% and number of interconnection links increased by 17%. While relative growth was larger for IPv6, absolute growth was larger in IPv4, our IPv4 AS graph gained 2,623 ASes and 22,343 links since our 2014 graph, while our IPv6 AS graph gained 980 ASes and 4,064 links. The three highest-degree (most-connected) IPv4 and IPv6 ASes in our measurements remained in the same position as in our 2014 data, but there were more changes in rank among lower-ranked IPv6 ASes than among similarly ranked IPv4 ASes. This difference in volatility is consistent with the younger and more dynamic growth pattern of IPv6. Examining the dynamics of changes in node degrees (number of neighbors) provides additional insights into the internet's evolutionary trends. Cande plots in Figures 2 and 3 illustrate the distributions of relative AS degree changes that occurred between 2014 and 2015. Each bin in those plots either includes all ASes that had the same degree in 2014 data or spans several degree values to include at least 25 ASes. For each bin, the black line in the middle shows the median percentage of change, the vertical box is drawn between the 25th and 75th percentile values, and the vertical line ends at the 5th and 95th percentile values.

Figure 4 (left) and 5 (right), (IPv4-IPv6 Top Ranked ASes) Figures 4 and 5 show changes in connectivity for the 10 IPv4 and 11 IPv6 ASes that were ranked in the "Top 10" by transit degree in either 2014 or 2015. In the IPv4 graph, 8 ASes increased their degree while 2 decreased, the median observed change was a 12% degree increase. The maximum degree growth of 55% was observed by Bharti Airtel (AS 9496). The largest increase moved Bharti Airtel from 10th to 5th position in the ranking of ASes by transit degree. The only decrease in degree from 2014 to 2015 came from AS 7019 and AS 3549, both degrees dropped by 4%, each which had a marginal impact on the Top 10 rankings. In the IPv6 graph, 9 ASes increased their degree, with a median increase of 20%.

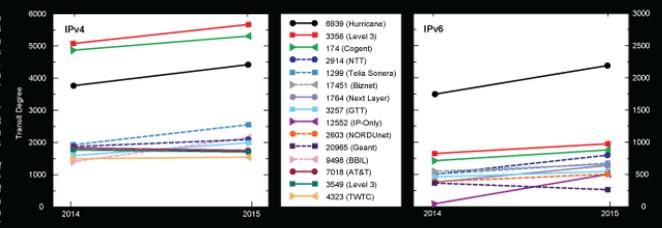


Figure 2 (Above), (Box-and-Whisker Plot IPv4) For ASes with degree less than 4 in 2014, the same number of ASes reduced and increased their AS degree by 2015. Fifty percent of ASes with degrees greater than 10 in 2014 saw at least a 0% increase in degree by 2015. Twenty five percent of those (degree > 10 in 2014) increased their degree by 22%.

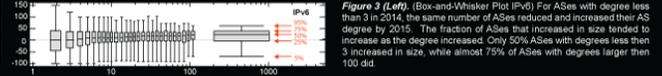
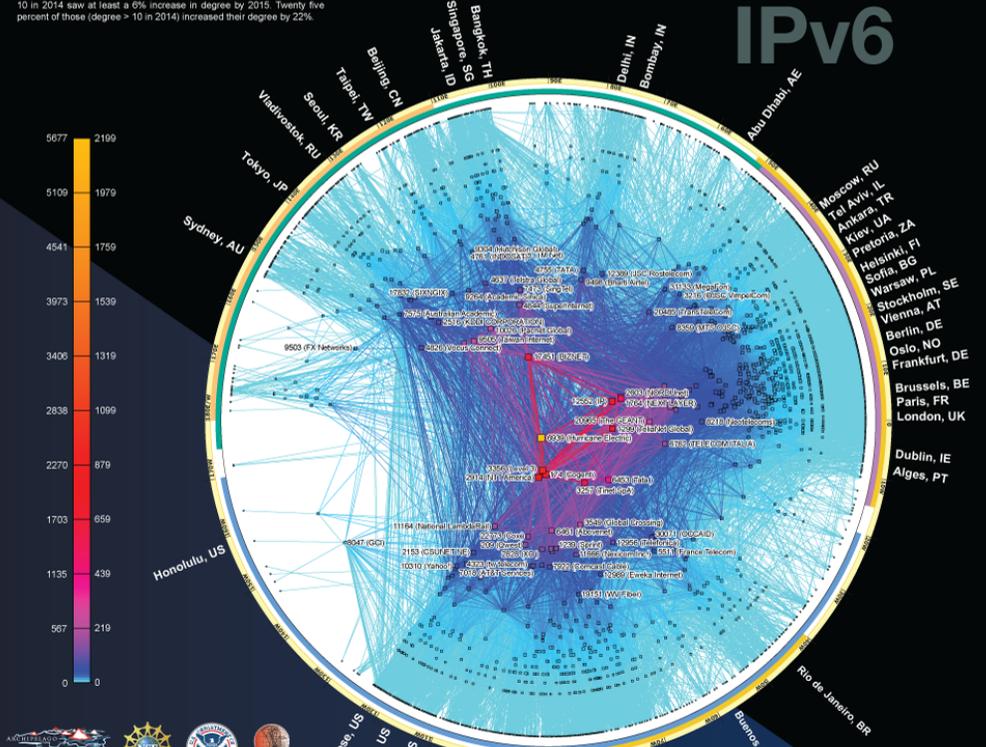


Figure 3 (Left), (Box-and-Whisker Plot IPv6) For ASes with degree less than 3 in 2014, the same number of ASes reduced and increased their AS degree by 2015. The fraction of ASes that increased in size tended to increase as the degree increased. Only 50% ASes with degrees less than 3 increased in size, while almost 75% of ASes with degrees larger than 10 did.

# IPv6



2015年1月

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ARK hosts: ANIR, APRNIC, AMS-IX, APNIC, APNIC-AS1, Asnic, BDOCOM Online Limited at BDOIX, CCNEX, CNIX, CAISIT, Central Communication Systems, Canada, Georgia Institute of Technology, Concordia State University, CSRI The US, DePaul University, Ecosis Limited University (ELTU), Eurocom, Foundation for Research and Technology - FORTH, FORTINET, FunFusion, GCI, Georgetown College, HD Networks, HEANET, Hong Kong Polytechnic University, Hurricane Electric, IRI, MIT, MITRE, National Science Foundation, National Computer Science Institute (CSI), National Systems Center, Iowa State University, Jacobs University Bremen, Jaguar Network, KISQ/CAE, Kollonetschki Zug, Level 3 Communications, Liberty Global, NCAIR,

	Number of IP addresses	Number of IP links	Number of ASes	Number of AS links
IPv4	42,048,676 (+12%)	33,899,736 (+9%)	39,809 (+7%)	152,438 (+17%)
IPv6	71,391 (+38%)	166,567 (+39%)	5,326 (+23%)	21,820 (+29%)

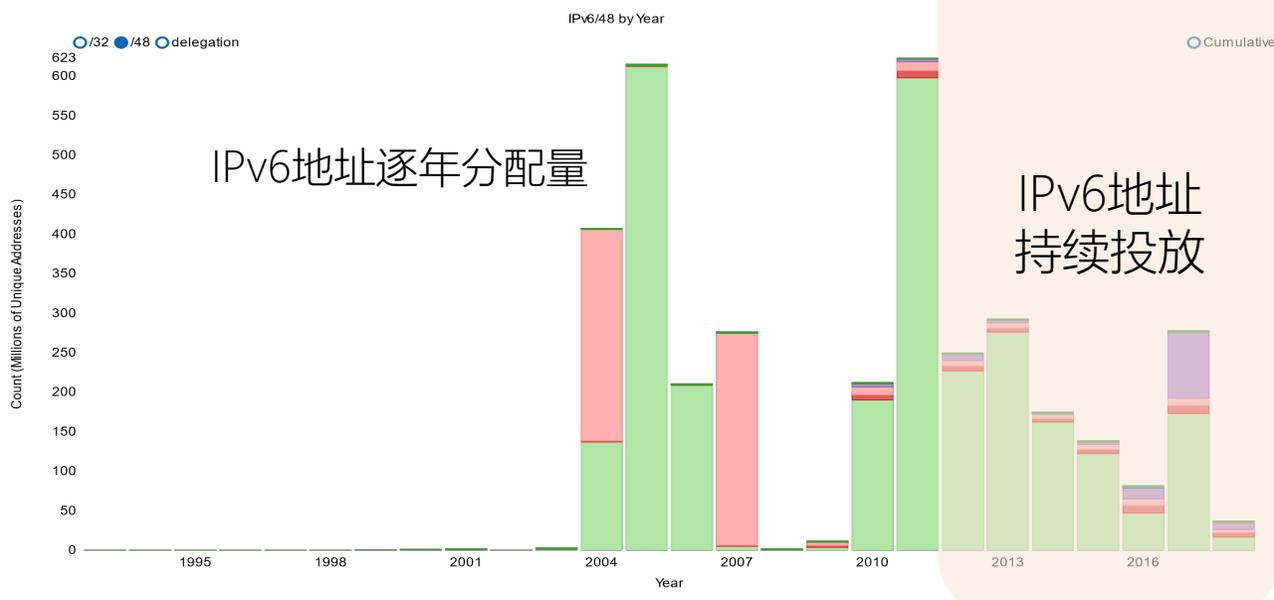
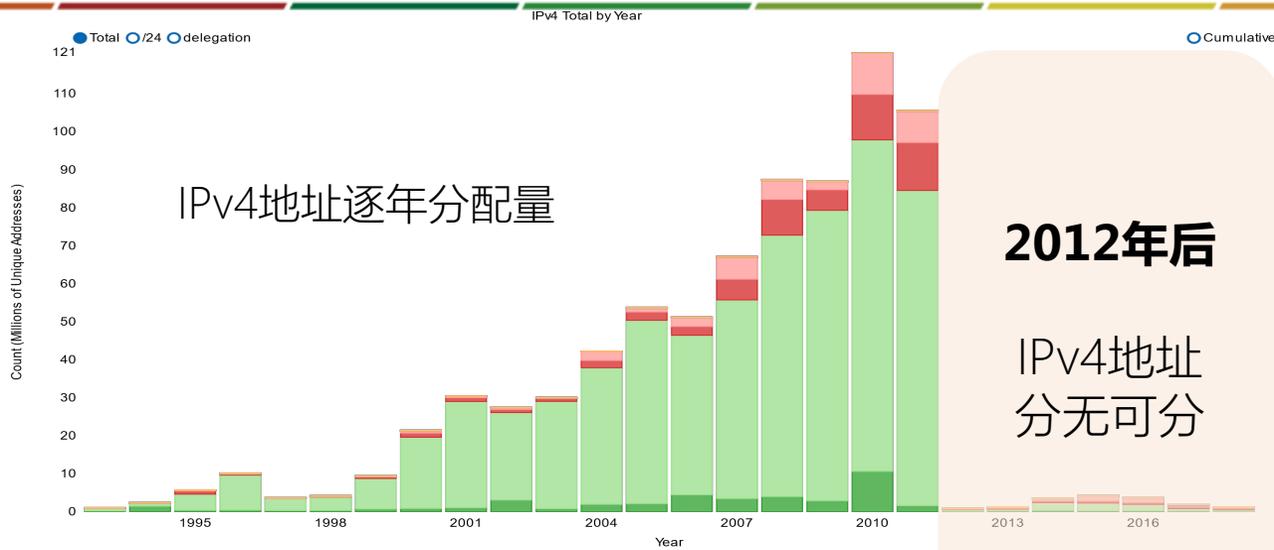


HIS, CHIR, HIC, Mexico, NORDUNET, Hoptel Research and Education Network, IRIIX, IRIIX-1, IRIIX-2, Northeastern University, Copernicus, as - al Espana, SESI, Cloud, Internet Exchange, Public University of Navarra, CCEI, RIPE NCC, RNP, Rede ANSP / Projeto NARA, Registro.br, SURFnet, Bielefeld Research Laboratory, Silesia Internet Exchange, Southern Methodist University, TUM, TUM-IT, Technical University of Munich, Thel, Tiscali, UCA2, US Army Research Lab, Univ, Telecom, Universitat Liria, Universidad Politecnica de Catalunya, University of Cambridge, University of Hawaii, University of Limerick, University of Melbourne, University of Napoli, University of Nevada at Reno, University of Oregon, University of Oklahoma, University of Washington, University of Zurich, VTR.

# 有点历史的“耗尽”



Geoff Huston, APNIC



数据来源 : <https://stats.apnic.net/#>

# IP地址空间分配情况



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## IPv4

我国3.4亿个地址，  
每互联网用户0.46个IP地址

	ISO- Index 3166 Code	Total /8s allocated	/32's allocated	% of IPv4 space	% of allocated space	/32s per user	/32s per capita	GDP per /32s
1	US	95.710449	1605754880	37.386894%	43.81%	5.528	4.892	11598
2	CN	20.282364	340281600	7.922798%	9.28%	0.460	0.240	32908
3	JP	12.163010	204061440	4.751176%	5.57%	1.764	1.607	24253
4	GB	7.291399	122329368	2.848203%	3.34%	1.977	1.831	21669
5	DE	7.276482	122079104	2.842376%	3.33%	1.683	1.481	28487

## IPv6

我国每互联网用户13.6万个IP地址

	ISO- Index 3166 Code	Total /64s Allocated	Allocated as Prefix	% of IPv6 space	% of allocated space	/64s per user	/64s per capita	GDP per /64
1	US	194444722700288	/16.53	0.001054%	9.50%	669376	592397	0.10
2	CN	101374115184640	/17.47	0.000550%	4.95%	136902	71463	0.11
3	DE	82248654716928	/17.77	0.000446%	4.02%	1134182	998080	0.04
4	GB	80062497357824	/17.81	0.000434%	3.91%	1293887	1198139	0.03
5	FR	53772996968448	/18.39	0.000292%	2.63%	951727	822292	0.05

数据来源：<https://labs.apnic.net/dists/v4cc.html>  
<https://labs.apnic.net/dists/v6cc.html>  
(截至2018年8月20日)

# IPv6的普及率



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截至2018年8月20日，本国IPv6用户占本国互联网用户比例排序

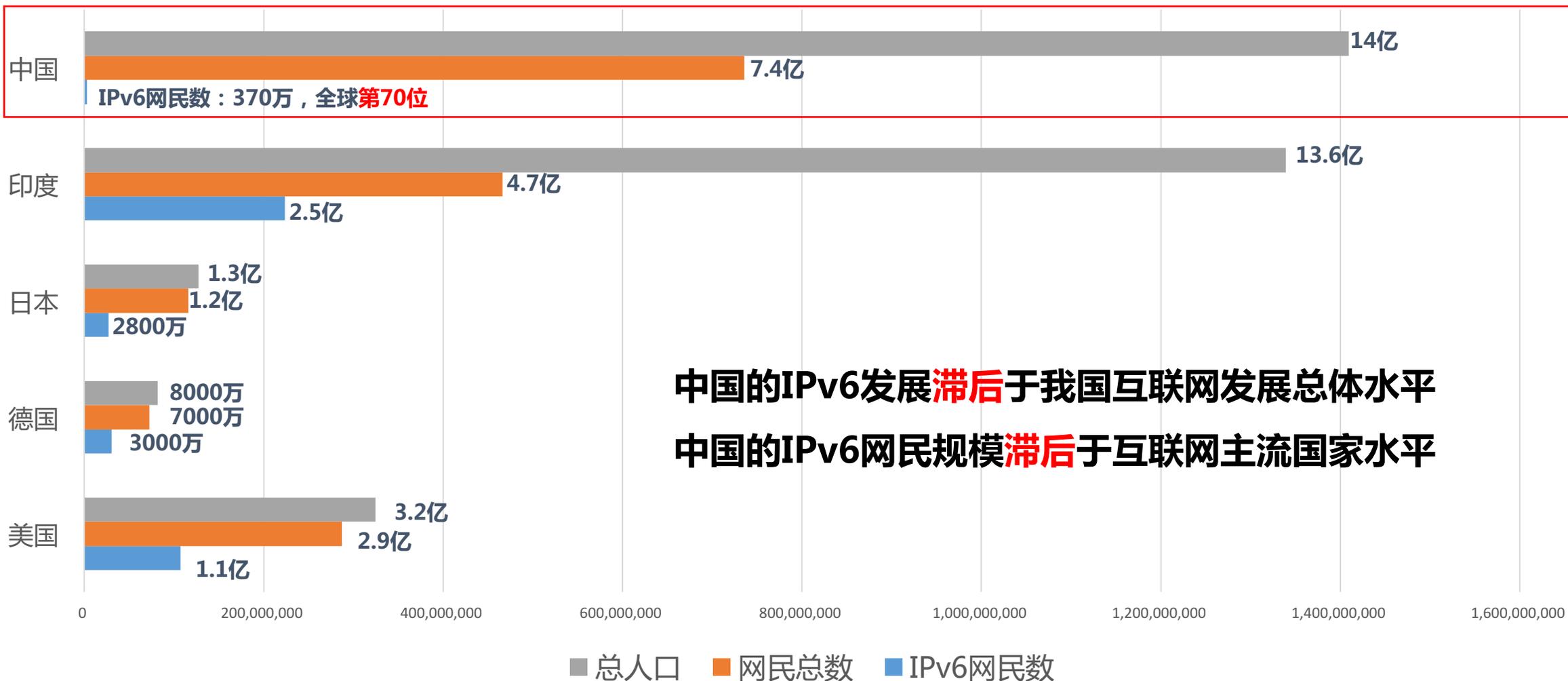
Index	ISO-3166 Code	Internet Users	V6 Use ratio	V6 Users (Est)	Population	Country
1	BE	10215064	57.98	5922801	11542446	Belgium
2	IN	474512735	52.73	250220859	1363542343	India
3	DE	72518006	41.57	30144907	82406826	Germany
4	US	290486505	41.30	119983857	328233340	United States of America
5	GR	7212928	37.26	2687208	11131062	Greece
6	CH	7488137	33.87	2536143	8587314	Switzerland
7	UY	2260479	32.59	736587	3477660	Uruguay
8	LU	566159	32.50	183978	594705	Luxembourg
9	GB	61877474	26.77	16562793	66822327	United Kingdom of Great Britain and Northern Ireland
10	JP	115694255	24.77	28657697	126996987	Japan

往下翻 ... 继续往下翻...

68	EG	33180693	0.66	217466	100547555	Egypt
69	KE	23292148	0.55	128948	51760330	Kenya
70	CN	740482542	0.50	3707029	1418548932	China
71	MD	1932609	0.50	9597	4034676	Republic of Moldova
72	LI	36693	0.46	169	38302	Liechtenstein

数据来源：<https://labs.apnic.net/dists/v6dcc.html>

# 几个国家之间的比较



中国的IPv6发展滞后于我国互联网发展总体水平  
中国的IPv6网民规模滞后于互联网主流国家水平

# 目录

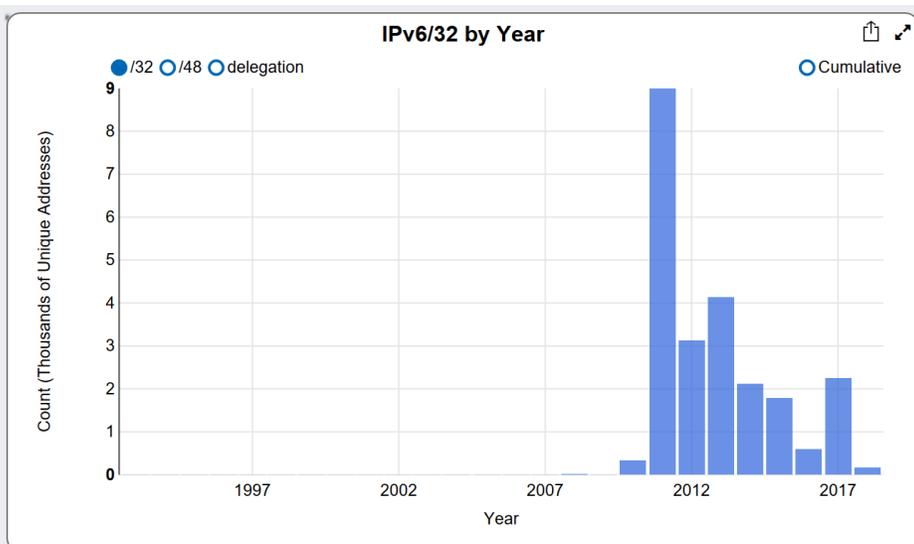
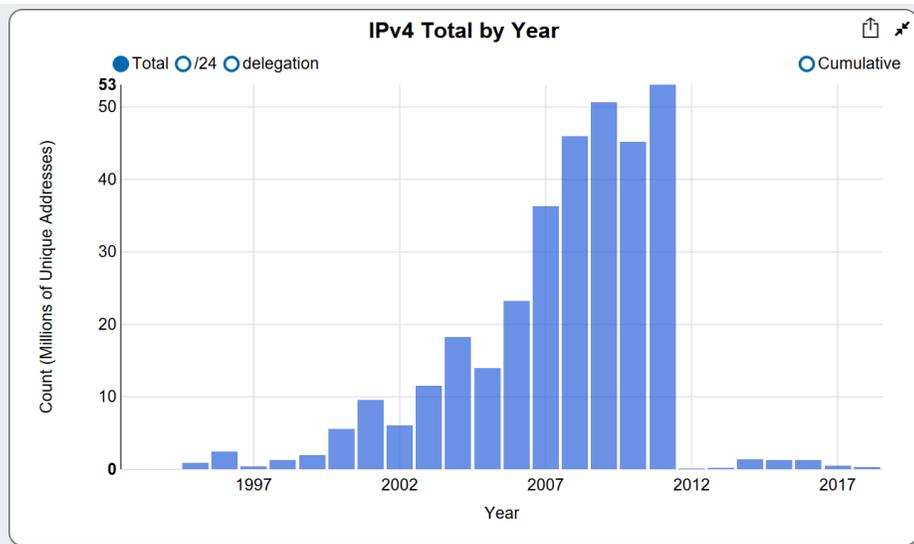
国际视图

我国视图

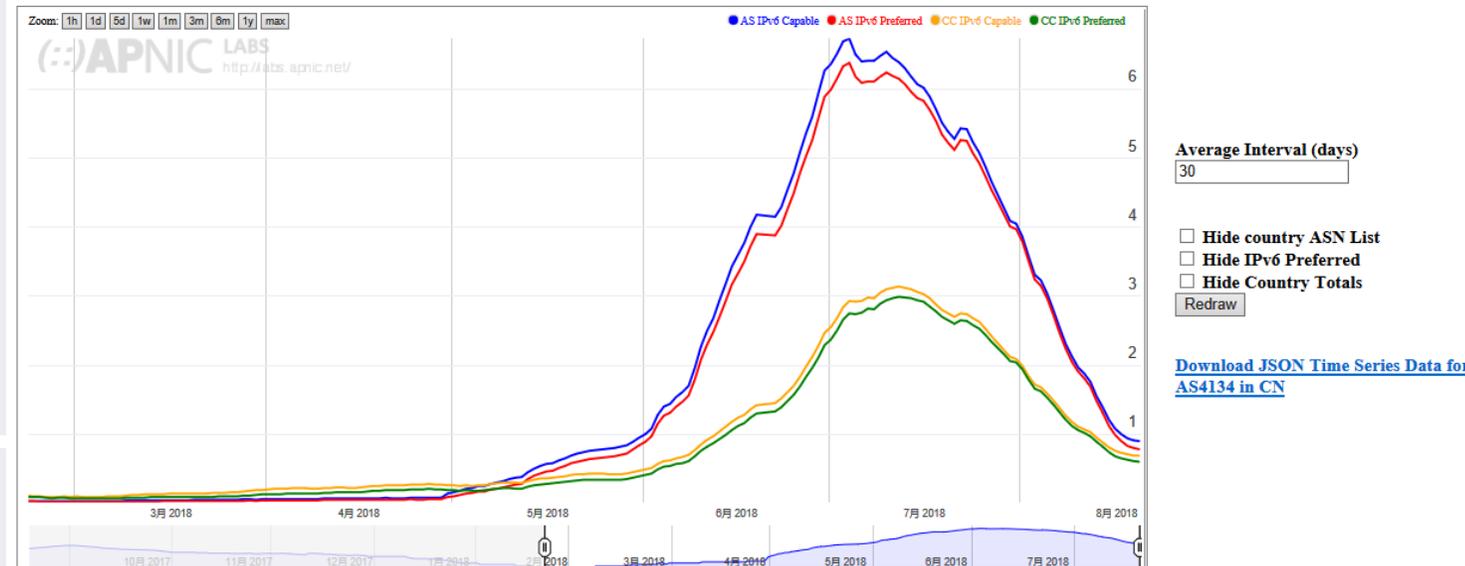
部署要求

实践情况

# 我国IPv6的部署情况



## IPv6 Per-Country Deployment for AS4134: CHINANET-BACKBONE No.31,Jin-rong Street, China (CN)



### Visible ASes in China

ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
<a href="#">AS4134</a>	CHINANET-BACKBONE No.31,Jin-rong Street	0.90%	0.78%	3,243,468
<a href="#">AS4837</a>	CHINA169-BACKBONE CHINA UNICOM China169 Backbone	0.10%	0.09%	1,578,896
<a href="#">AS45090</a>	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited	0.01%	0.01%	339,392
<a href="#">AS4812</a>	CHINANET-SH-AP China Telecom (Group)	0.49%	0.41%	277,070
<a href="#">AS56041</a>	CMNET-ZHEJIANG-AP China Mobile communications corporation	0.70%	0.66%	242,998
<a href="#">AS9808</a>	CMNET-GD Guangdong Mobile Communication Co.Ltd.	0.66%	0.63%	241,034
<a href="#">AS4808</a>	CHINA169-BJ China Unicom Beijing Province Network	0.38%	0.35%	235,552
<a href="#">AS63646</a>	XJKJ Beijing Little Orange Tech. Co., Ltd	0.01%	0.01%	192,938
<a href="#">AS24547</a>	CMNET-V4HEBEI-AS-AP Hebei Mobile Communication Company Limited	0.12%	0.10%	85,652
<a href="#">AS56044</a>	CMNET-AS-LIAONING China Mobile communications corporation	0.98%	0.93%	71,438
<a href="#">AS24400</a>	CMNET-V4SHANGHAI-AS-AP Shanghai Mobile Communications Co.,Ltd.	0.82%	0.78%	62,774
<a href="#">AS17816</a>	CHINA169-GZ China Unicom IP network China169 Guangdong province	0.35%	0.33%	59,772
<a href="#">AS56047</a>	CMNET-HUNAN-AP China Mobile communications corporation	0.45%	0.44%	58,668

# 目录

国际视图

我国视图

部署要求

实践情况

## 2017.11.26，我国正式发布《推进互联网协议第六版（IPv6）规模部署行动计划》



- **国家行动**：首次中办、国办联合发文，新华社、人民日报全文刊载
- **目标明确**：推动互联网向IPv6的升级演进

- **应用牵引**：着力弥补IPv6应用短板，强化互联网应用的需求拉动作用
- **细分场景**：在社会治理、公共安全视频监控、安全生产、健康医疗、教育、社保、工业互联网等领域采用IPv6技术

- **政府先行**：强制要求升级政府、中央媒体、中央企业网站
- **规模发展**：用 5 到10 年时间，建成全球最大规模IPv6 商业应用网络

1

## 一条主线

以协同推进IPv6 规模部署为主线

2

## 两个切入

- **典型应用改造**：用户量大、服务面广的门户、社交、视频、电商、搜索、游戏等
- **特色应用创新**：支持地址需求量大的特色IPv6应用创新与示范，如宽带中国、“互联网+”、新型智慧城市、工业互联网、云计算、物联网等

3

## 三大举措

- **典型应用先行**：以应用为切入点和突破口
- **移动固定并举**：抓住移动网络升级换代和固定网络“光进铜退”发展机遇，统筹推进移动和固定网络的IPv6 发展
- **增量带动存量**：新增网络设备、应用、终端全面支持IPv6，带动存量设备和应用加速替代

国家网信办牵头，委托信通院实时监测，定期发布IPv6规模部署监测报告

# IPv6规模部署行动计划重点工作



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2017~2018

2019~2020

## 支持IPv6接入，提供IPv6服务

- TOP50商业网站
- 省部级政府网站
- 省级新闻广电媒体网站
- 央企网站
- 新型智慧城市应用
- TOP100商业网站
- 地市级政府网站
- 地市新闻广电媒体网站
- 地方国企网站
- 工业互联网IPv6应用

应用  
服务

基础  
设施

2017~2018

2019~2020

## IPv6活跃用户2亿→达到5亿

- 骨干网IPv6互通、国际IPv6进出口建设扩容
- 城域网、接入网、4G网络IPv6升级改造
- 超大型数据中心IPv6升级改造
- CDN与DNS升级、IPv6发展监测平台建设
- 基础电信企业集采的固定终端、移动终端
- 广播电视网络与融合终端

2017~2018

2019~2020

## 加强IPv6核心技术研发

- 网络路由
- 网络过渡
- 网络管理
- 网络智能化
- 网络虚拟化及网络安全
- 新型编址与路由
- 内生网络安全
- 网络虚拟化

关键  
技术

网络  
安全

2017~2018

2019~2020

## 推进IPv6 网络安全提升

- 落实IPv6地址编码规划
- 升级改造现网安保系统
- IPv6网络安全管理及机制研究
- 落实网安等级保护制度
- 落实网络实名制
- IPv6地址备案管理办法

# IPv6规模部署行动计划实施步骤



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## 2017-2018

### 应用系统

- 国内用户量排名前50位的商业网站及应用
- 省部级以上政府和中央企业外网网站系统
- 中央和省级新闻及广播电视媒体网站系统
- 工业互联网等新兴领域的网络与应用
- 域名托管服务企业、顶级域运营机构
- 域名注册服务机构的域名服务器
- 超大型互联网数据中心（IDC）
- 排名前5位的内容分发网络（CDN）
- 排名前10位云服务平台的50%云产品

### 管道

- 骨干网/网间互联/城域网/接入网
- LTE网络及业务
- 广电骨干网

### 终端

- 新增网络设备、固定网络终端、移动终端。

到2018年末，市场驱动的良好发展环境基本形成，IPv6活跃用户数达到2亿，在互联网用户中的占比不低于20%

## 2019-2020

### 应用系统

- 新增网络地址不再使用私有IPv4地址
- 国内用户量排名前100位的商业网站及应用
- 市地级以上政府外网网站系统
- 市地级以上新闻及广播电视媒体网站系统
- 大型互联网数据中心
- 排名前10位的内容分发网络
- 排名前10位云服务平台的全部云产品

### 管道

- 广电网络
- 5G网络及业务
- 国际出入口

### 终端

- 各类新增移动和固定终端

到2020年末，市场驱动的良好发展环境日臻完善，IPv6活跃用户数超过5亿，在互联网用户中的占比超过50%

## 2021-2025

- 到2025年末，我国IPv6网络规模、用户规模、流量规模位居世界第一位
- 网络、应用、终端全面支持IPv6
- 全面完成向下一代互联网的平滑演进升级，形成全球领先的下一代互联网技术产业体系。

到2025年末，我国IPv6网络规模、用户规模、流量规模位居世界第一位，形成全球领先的下一代互联网技术产业体系。

发展路径：遵循典型应用先行、移动固定并举、增量带动存量的发展路径，以应用为切入点和突破口，重点加强用户多，使用广的典型互联网应用的IPv6升级，强化基于IPv6的特色应用创新，带动网络、终端协调发展。

# 目录

国际视图

我国视图

部署要求

实践情况

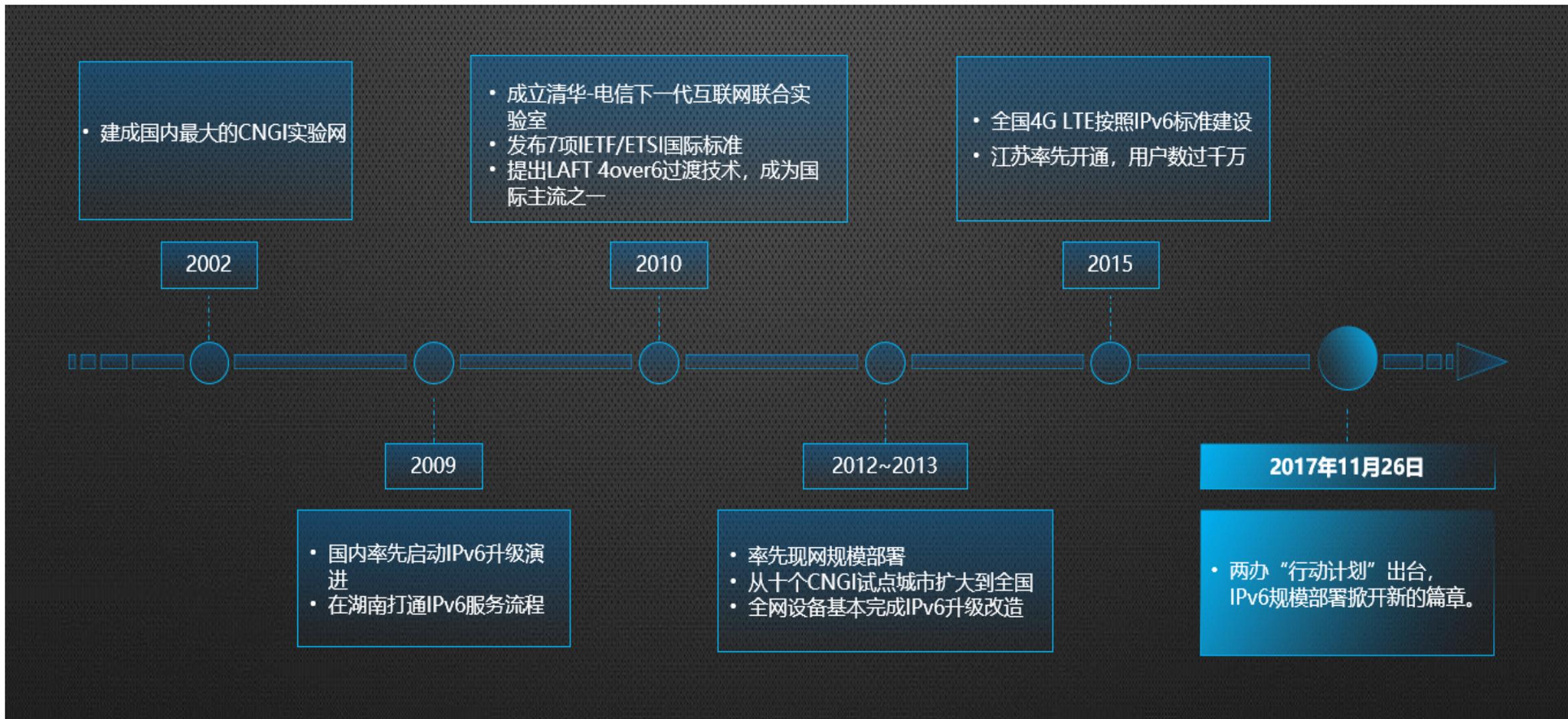
# 中国电信对IPv6进行了持续研究和实践



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# “行动计划”发布以来，中国电信系统推进，成效显著



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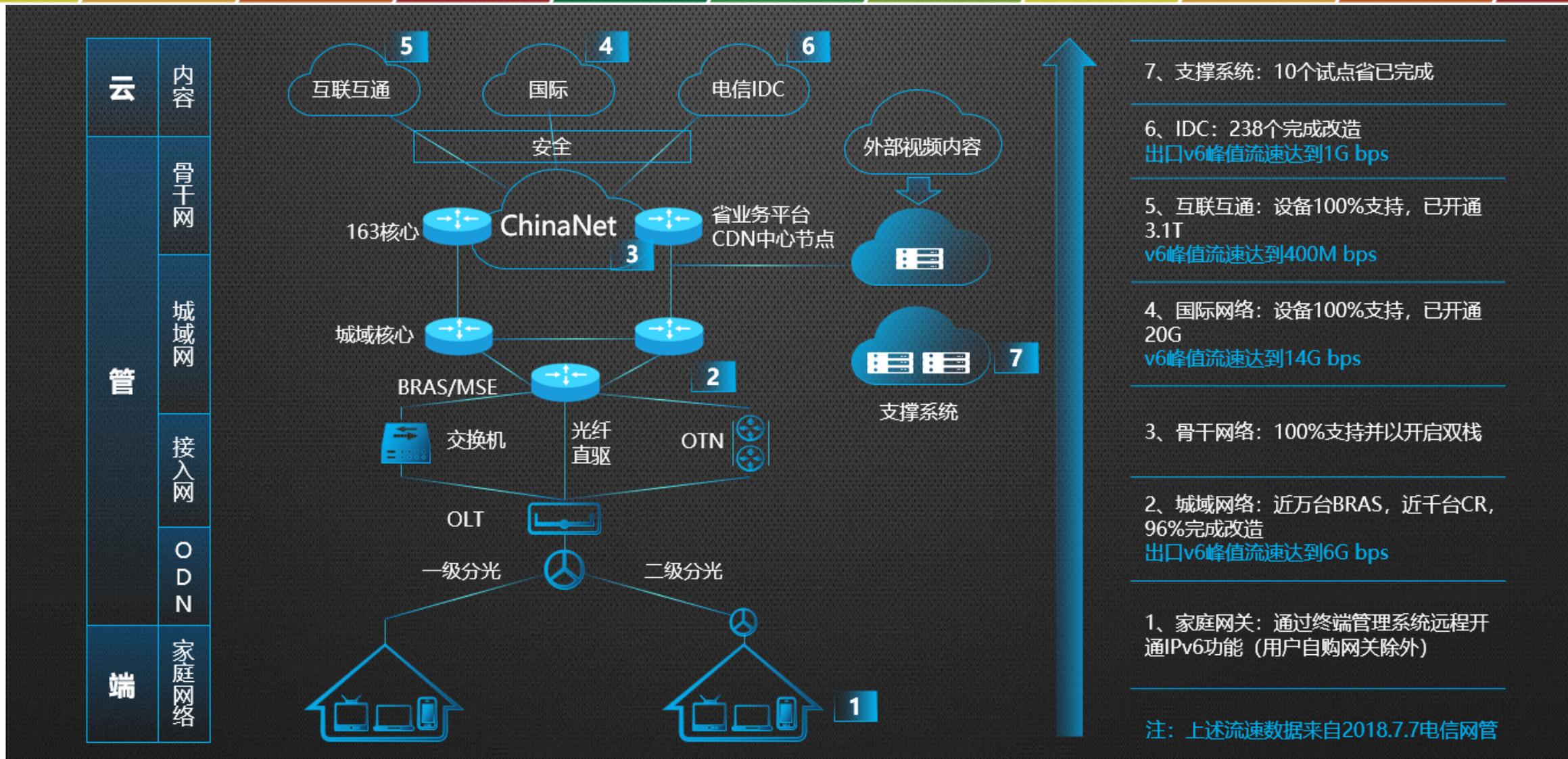


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在网络已基本具备IPv6能力的情况下，工作重点由前期的网络改造为主向**完善IPv6业务服务能力**方向转变

网络改造与开通	能力普查、全面开启、不留死角	<ul style="list-style-type: none"><li>移动网已开通<b>156</b>个城市，共<b>1.29亿</b>用户。</li><li>固网IP设备<b>5500+</b>台已开启双栈，开通用户<b>870万</b>。</li></ul>
	开通国际出口	<ul style="list-style-type: none"><li>开通国际出口<b>20G</b>，流量增长迅速</li></ul>
	开通与兄弟运营商互联互通	<ul style="list-style-type: none"><li>与联通、移动完成京沪穗郑蓉五地互通，带宽共<b>3.14T</b>；</li><li>与教育网完成京沪穗三地互通，带宽为<b>36.31G</b></li></ul>
自营业务改造	门户、189邮箱、掌厅等改造	<ul style="list-style-type: none"><li>门户网站、189邮箱完成改造</li></ul>
产品及服务提供	IPv6专线产品流程打通	<ul style="list-style-type: none"><li>全国具备对重点客户的开通及服务能力</li></ul>
	IDC升级及流程打通	
	网站改造咨询集成服务	<ul style="list-style-type: none"><li>主动对接客户，针对央企举办了<b>2次</b>大型培训</li></ul>
运营体系升级	运营支撑系统的升级改造	<ul style="list-style-type: none"><li>网管具备对于设备和流量监控能力</li><li>4G网络运营系统完成升级支持开通IPv6</li></ul>

# 宽带网络设备基本完成改造



- 7、支撑系统：10个试点省已完成
- 6、IDC：238个完成改造  
出口v6峰值流速达到1G bps
- 5、互联互通：设备100%支持，已开通3.1T  
v6峰值流速达到400M bps
- 4、国际网络：设备100%支持，已开通20G  
v6峰值流速达到14G bps
- 3、骨干网络：100%支持并以开启双栈
- 2、城域网络：近万台BRAS，近千台CR，96%完成改造  
出口v6峰值流速达到6G bps
- 1、家庭网关：通过终端管理系统远程开通IPv6功能（用户自购网关除外）

注：上述流速数据来自2018.7.7电信网管

# IPv6流量情况 - 省出口, 2018年8月20日



# IPv6流量情况 - 互联互通, 2018年8月20日

## 中国电信IPv6流量情况



各省出口带宽

160389.439 G



互联互通带宽

3176 G



移动带宽

4380 G



国际出口带宽

20 G



单位: Mbps



单位: Mbps



单位: Mbps



# IPv6流量情况 - 国际出口, 2018年8月20日

## 中国电信IPv6流量情况



各省出口带宽

160389.439 G



互联互通带宽

3176 G



移动带宽

4380 G



国际出口带宽

20 G

欧洲区	电路(条)	带宽(G)
Peer	28	652.7
Transit	0	0.0
Customer	169	57.6

亚太区	电路(条)	带宽(G)
Peer	29	200.5
Transit	0	0.0
Customer	511	486.1

美洲区	电路(条)	带宽(G)
Peer	30	475.0
Transit	4	40.0
Customer	190	465.6



4.838 Gbps

8月忙时流速

4.121 Gbps

8月平均流速

9.64 Gbps

8月峰值流速

上海/移动民生C3-上海/南汇信息园区I5-10G(上海/移动民生-南汇信息园区/10GE9450IP)



上海/移动民生C4-上海/南汇信息园区I6-10G(上海/移动民生-南汇信息园区/10GE9451IP)



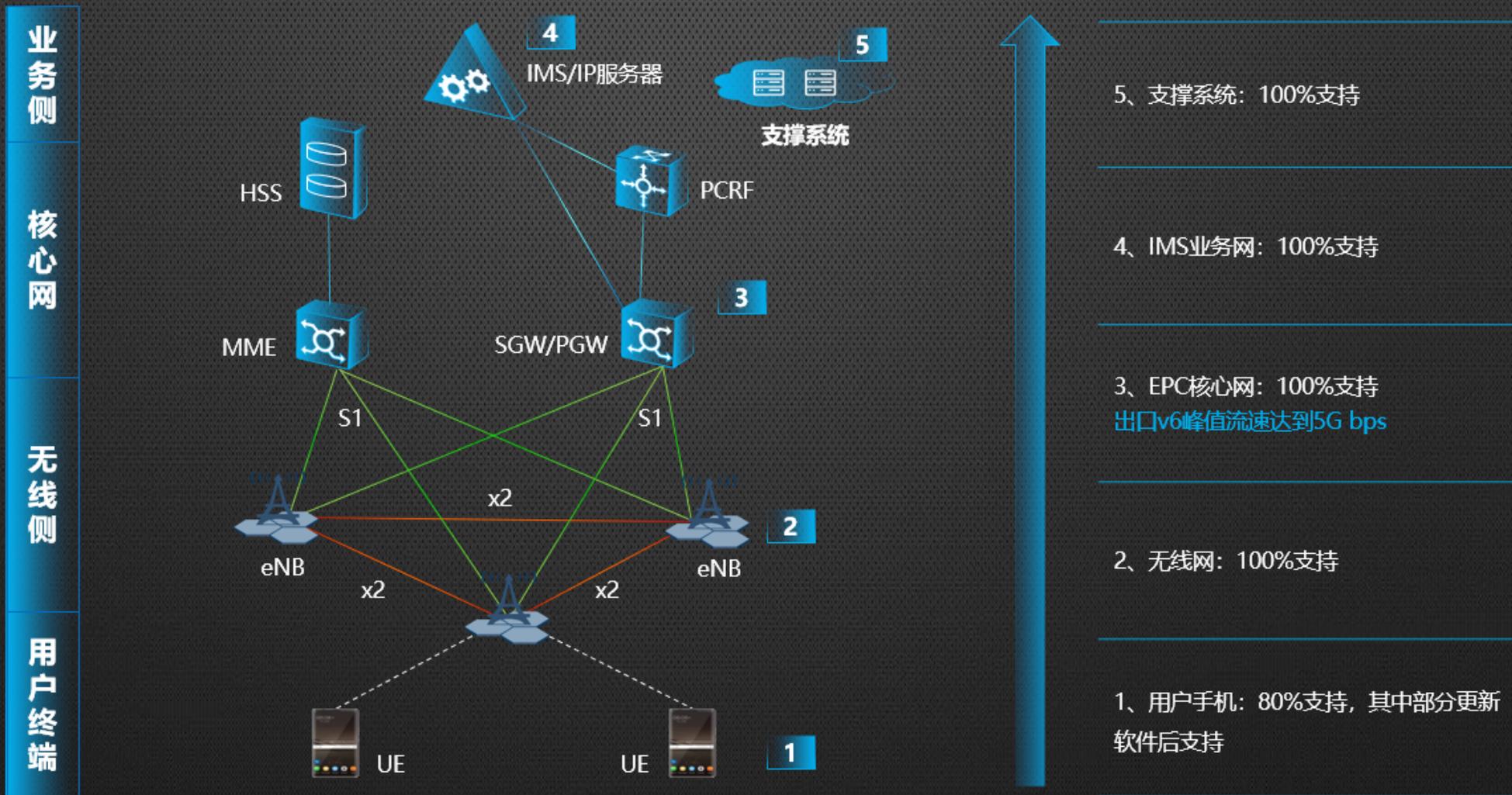
# 4G移动网络全部支持



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# 中国电信IPv6流量情况 - 移动网, 2018年8月20日





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同仁们，还未如愿见着不朽  
莫把自己先搞丢  
沉着冷静的面对v6的挑战

2018 ISC 互联网安全大会 中国·北京  
Internet Security Conference 2018 Beijing·China  
(原中国互联网安全大会)