The Internet of Things through IPv6: An Analysis of Challenges, Solutions and Opportunities

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Abstract: *The IPv6 Deployment worldwide is becoming a reality now with some countries achieving more than 10 % user penetration with Belgium (26.68%) and Switzerland (13.74%) at the top ranking (http://labs.apnic.net/dists/v6dcc.html) and reaching double digits v6 coverage on Google IPv6 stats. May Autonomous Networks (ASN) reach more than 50% with v6 preferred or v6 capable: (http://labs.apnic.net/ipv6-measurement/Economies/US/). Over 50 Million users are accessing Internet over IPv6 and probably not even knowing it. The US remains by far the biggest adopter of IPv6 with some 22 Million users followed by Germany, Japan and China with some 5 M users. Worldwide IPv6 deployment has passed the 4 % Google usage bar doubling every 6 months (http://www.google.com/intl/en/ipv6/statistics.html). If this trend continues, we should achieve 50% by 2017 which would be the inflection point when the full roll-out of IPv6 becomes a strategic plumbing decision of the networks, a topic that is avoided so far due to many strategic and resources issues (lack of top management decision-making, lack of v6 skilled engineers and v6 deployment best practices, very limited ISP v6 access deployment, ..).*

The public IPv4 address space managed by IANA (http://www.iana.org) has been completely depleted by Feb 1st, 2011. This creates by itself an interesting challenge when adding new things and enabling new services on the Internet. Without public IP addresses, the Internet of Things capabilities would be greatly reduced. Most discussions about IoT have been based on the illusionary assumption that the IP address space is an unlimited resource or it is even taken for granted that IP is like oxygen produced for free by nature. Hopefully, the next generation of Internet Protocol, also known as IPv6 brings a solution. In early 90s, IPv6 was designed by the IETF IPng (Next Generation) Working Group and promoted by the same experts within the IPv6 Forum since 1999. Expanding the IPv4 protocol suite with larger address space and defining new capabilities restoring end to end connectivity, and end to end services, several IETF working groups have worked on many deployment scenarios with transition models to interact with IPv4 infrastructure and services. They have also enhanced a combination of features that were not tightly designed or scalable in IPv4, such as IP mobility and ad-hoc services, catering for the extreme scenario where IP becomes a commodity service enabling lowest cost networking deployment of large scale sensor networks, RFID, IP in the car, to any imaginable scenario where networking adds value to commodity. For that reason, IPv6 makes feasible the new conception of extending Internet to consumer devices, physical systems and any imaginable thing, that can be benefited of the connectivity. IPv6 spreads the addressing space in order to support all the emerging Internet-enabled devices. In addition, IPv6 has been designed to provide secure communications to users and mobility for all devices attached to the user; thereby users can always be connected. This work provides an overview of our experiences addressing the challenges in terms of connectivity, reliability, security and mobility of the Internet of Things through IPv6. This paper describes the key challenges, how they have been solved with IPv6, and finally presents the future works and vision that describe the roadmap of the Internet of Things in order to reach an interoperable, trustable, mobile, distributed, valuable, and powerful enabler for emerging applications such as Smarter Cities, Human Dynamics, Cyber-Physical Systems, Smart Grid, Green Networks, Intelligent Transport Systems, and ubiquitous healthcare.

The deployment of Carrier-grade NAT is in full swing making networking and user experience more brittle. The security and cybersecurity issues are like always brushed over at this stage due mainly to lack of IPv6 security skills. New topics are more on the lime light such as Cloud Computing, Internet of Things, SDN, NFV, 5G,… However, these fields are taking IP networking for granted designing them on IPv4/NAT building non-scalable and non-end to end solutions. The IPv6 Forum is driving new initiatives to garner support and create awareness in these are with initiatives such as the IEEE Comsoc IoT, SDN-NFV and 5G: www.ipv6forum.org