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	Next Generation Applications Working Group Report
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1. Introduction

Millions of people navigate the Internet today with relative ease. Unlike early netizens, they don't have to rely on news groups, bulletin boards, and word of mouth to find their way around. Gone are the days when using the Internet required learning arcane commands to copy files or send e-mail. But, despite the user-friendliness of Web browsing, there is still a lot of software "plumbing" that the people who set up networks have to grapple with on a daily basis. Each entity on the Internet, for instance, needs a unique address. The trouble is that, like phone numbers, the addresses are getting used up.

Ease of use has led to exponential growth, which has raised the question: Can the method by which data is sent from one computer to another on the Net -- the Internet Protocol, or IP -- keep up with the demand? The current version of IP is IPv4, and it has been in use for over 20 years; a remarkable fact in itself when one considers the commercialisation of the “web” has only occurred significantly in the last 5 years.

While the basic Internet protocol, IP, has been around for more than 20 years, the Web was only conceived around 10 years ago (in Europe, at CERN); thus the Internet’s current killer application was not invented until 10 years after its underlying enabler, IPv4, was. As we move towards IPv6, we should note that IPv6 is ultimately an enabler, one that makes networked application development much simpler and cleaner for developers, and one that will likely yield a new killer application in the coming decade. By deploying IPv6 early, we help current application areas such as 3G, but we also give Europe a jump-start towards a new e-economy, and future innovation for the benefit of both business and society.

In considering whether IPv4 can continue to succeed, it is very important to consider the requirement for end-to-end global addressing, from any one IP-based network to any other, e.g. the ability of a user travelling with an IP-enabled device to contact and interact with an IP-enable device in their home. While one can currently connect *out* from the home with relative ease, one cannot connect *in* to multiple devices; that is where the address space issue becomes pressing.

Equally important, will that method be flexible enough to grow, evolve, and support the features that the new Net economy will require?

The answer is a resounding “yes” with, and only with, the introduction of IPv6, a significant enhancement that maintains everything that's good about IP and adds much more. Making IP more scalable -- and added features to improve it based on the huge amount of actual experience with the Internet, sustaining the open, standards-based benefit of an end-to-end network model and recognising that end-to-end IP security is a must. So it's one of the many additions included with IPv6. End-to-end security is an option with IPv4, but with IPv6, it's standard.

These days, people are more mobile. Everybody seems to be taking laptops, pagers, PDAs, and wireless phones with them wherever they go. With time, these devices will all be IP-enabled, and there simply won't be enough IPv4 addresses to allow all such devices to be globally reachable.

Finally, and perhaps most importantly, we need to make IP easier for administrators to manage. IPv6 is more scalable, so more addresses can be allocated. But that implies more systems, so IPv6 includes a number of auto-configuration features, enabling the missing ease-of-use functionality of “plug and ping” to the Internet, generating a raft of next generation applications that should be agnostic of the underlying infrastructure. In short, the best attributes of IP are kept within IPv6, and more have been added where they are needed and can do the most good, making the Internet significantly more *scalable* and adding functionality that wasn't even imaginable 20 years ago.

So, a special commitment is needed to progress the European industry and the public at large to deploy IPv6 as the solution for tomorrow's demands on the Internet.

2. Trends related to next generation Internet applications

There are a number of trends that we can identify related to new, next generation applications:

- We will be confronted with a large diversity of devices, such as:
    - Handheld and mobile (cellular phones, PDA’s, webpads, portable computers)
    - Wearable computing devices (on the body and in clothing)
    - Embedded smart devices, sensors and actuators
- There will be evolution in networks, such as:
    - Several variants of wireless networks (indoor and outdoor) with their own characteristics with respect to bandwidth, set-up, etc. and which offer ad-hoc as well as controlled (managed) connections.
    - Several types of wired networks, within scenarios such as the home, car and public buildings and also for access networks
    - More and more networks will move to the always-on connected type; these networks will require permanent IP addresses (unlike the temporary IP addresses assigned to dial-up devices).
    - Bandwidth as well as quality of service will continue to improve. However, there needs to be national government action to push deployment of broadband Internet such as xDSL. Quality of service can come from network capacity over-provisioning, as well as classic IP QoS techniques (e.g. differentiated services).

- o Roaming of mobile devices across networks is needed; this includes horizontal handover across cells from a network as well as vertical handover across different networks. Users may expect to roam from a wireless LAN network where it is available to a GSM, GPRS or 3G network if a faster, cheaper alternative is not available. This has an impact on available bandwidth and connection charges for the user.

- o GRID networks, where high-capacity links are put in place to enable widely distributed processor clusters to handle and exchange data. The GRID philosophy views the network and associated computing resource as a “power”-like utility service. Research in optical networking will lead to new, very high-speed networking.

- There will be new types of services:
  - o Infotainment services offering all kinds of media formats in need of support for non-streaming as well as streaming data, including real time captured streaming data.
  - o Multi media communications services, including video-conferencing and shared applications (e.g. shared viewing with Instant Messaging or audio/video conference).
  - o Location-based services for people on the move, and allowing location-specific content to be offered and delivered to users.
  - o An increase in push-based services.
  - o Inter-device communications, with the introduction of smart, agent-based systems.
  - o Mobility of users as well as devices and applications is required

People with their electronic outfits will move through all kinds of handoff-aware spaces which will have their networking facilities. People expect that these spaces are aware of their presence and support them in their activities and give them access to services mentioned above. This puts high demands on features such as:

- o Ease of use:
  - No system administrator
  - Interoperability across several transport networks
  - Ad-hoc network connections
  - Broadband always-on
- o Mobility (horizontal and vertical handover)
- o Dynamic configurable and adaptable networks and services
- o Safe and secure

- o Quality of service
- o Address ability of devices

Some of these needs can be fulfilled by IPv4 together with a number of extensions. IPv4 has been patched over the years to cope with the Internet's evolution, but those patches are now hitting limits, primarily in the forthcoming shortage in global IPv4 address space. IPv6, however, covers most of these needs through: address space, auto-configuration, neighbour discovery and mobility support.

A person with his own electronic "aura" moves around and will be part of several environments where he wants to be recognized and be able to use the facilities from this environment in a transparent way.

3. Examples of applications

There are many applications that will emerge in the next generation Internet following the trends described in Section 2 above. IPv6 will allow application developers to design these applications without having to be limited by the restrictions of IPv4 addressing and in particular NAT.

It should be noted that in a "Net 10" NAT environment, there is a theoretical ceiling of 2^{24}, or 16 million hosts when using such private addressing. However, because of the difficulties in reality of using all that address space[1], and the inevitable scaling issues in providing the devices to perform the NAT translation, the practical limit on a network running IPv4 NAT will be much lower, and likely to be no more than 5 million hosts. Any operator looking to deploy an IP network using IPv4 NAT should consider the future growth of that network. If they intend to offer more than a few million hosts, IPv4 NAT will struggle to cope; IPv6 is then the only viable solution.

3.1. Multi-user networked games

Multi-user networked games are an important class of applications. These applications require fast communication between the partners involved to exchange game commands instantly between the participants. Fast responses, and low latency, are key features of many action-oriented games. Connecting game machines to the network should be a trivial task. Mobile game machines using cellular networks will come up and put those requirements also on the underlying networks. A need for high bandwidth will grow for games that use scenes from the real world as context.

3.2. Ad-hoc networking

Wireless LANs (802.11b) are currently very popular. Early deployments exist in public places such as hotels and airport lounges. With IPv6, ad-hoc networking is made easier through plug and play networking, and users can enjoy the ability to receive inbound connections to their devices (laptops or PDAs) as well as initiating connections out from their current location. Wireless LAN access will be a big driver for public Internet access, and IPv6 will make that access richer.

3.3. Collaborative working

In this context, we see applications in the enterprise world. Some emerging application areas include:

- In offices, such as video-conferencing including remote application sharing. Applications like these require connections between the end-terminals; quality of service management with respect to bandwidth for video as well as low delay for interaction with remote application sharing; secure connections and security at application level.
- Distributed engineering support environment to data consistency and workflow. Peer-to-peer technology offers new opportunities to this complex problem. Security, community support and management are essential to this kind of applications, with links to profile management and authentication for role-based access control to data as well as application functions.
- Mobile employees using all kinds of portable equipment or devices at different locations. These mobility aspects put strong needs on the mobility of persons and devices across

[1] The Host-Density Ratio for Address Assignment Efficiency, http://www.ietf.org/rfc/rfc3194.txt

several networks. This translates into needs in terms of roaming across networks; adapt to different network characteristics (adapting the kind or format of data to i.e. available bandwidth); adapt to different device characteristics with respect to i.e. display properties and of course strong security requirements with respect to authentication and secure transport.

Distributed learning using video-conferencing technology is another example of the use of collaboration technology. Several examples exist, from Spain up to the north of Sweden. The use of multicasting (which is an integral part of IPv6) is proven to give excellent results for such environments. Also the use of SIP to set-up a session is recommendable since this would allow the use of a mix of computer based devices, PDAs and multi-media phones in one session.

3.4. Home networking

It is expected that a home network will be a collection of heterogeneous network media (such as Ethernet IEEE1394 "firewire", Wireless LAN, Bluetooth, Zigbee, power line and maybe Home PNA), which are expected to work seamlessly together. Access by the owner from remote locations is expected to put tough requirements on access control to keep out intruders. Broadband connections and always-on connections offer opportunities for new kinds of applications, especially in peer-to-peer mode. To make this possible we need:

- Plug and play for networked devices. Set-up and management of these networks should be easy not requiring special skills, e.g. for typical people in their homes. The IPv6 auto-configuration facilities were designed to address this issue.

- Device and service discovery are important to make applications work also in an environment where devices can be switched on and off or where mobile devices are entering or leaving the network.

- Security facilities to protect your home network from intruders are an important aspect. The IPsec facilities will offer the right mechanisms for built-in implementations. The IPv4 NAT implementation is showing its limitations of end-to-end transparency and security.

- User and device Mobility, inside the home as well as outside, is an important function. It should be possible to contact a person wherever they are, and the users of a home network should able to access the home applications wherever they are.

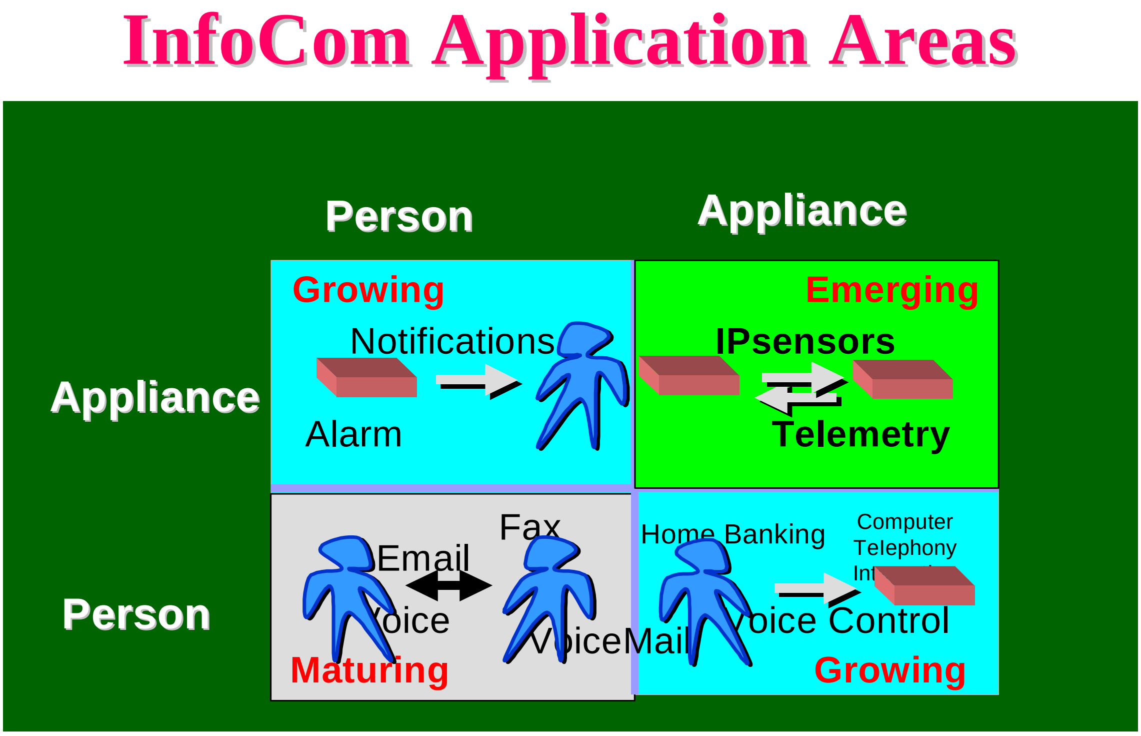
- Since the home network will consist of at least a couple of network media that are expected to work together, bridging and routing within such an environment are important.

3.5. Peer-to-peer applications

The most popular applications on today's Internet, outside of the Web, are "people applications", where users exchange data directly. With IPv4, this generally has to be done via an intermediate server machine, because with IPv4 NAT it is very difficult to initiate connections into computers inside home networks.

Examples of such applications include ICQ (instant messaging) and Napster (file exchange, most notoriously MP3 music files). With devices anywhere on an IPv6 Internet directly addressable, the potential for future peer-to-peer applications is massive. With broadband Internet to the home, and 3G mobiles, it may become possible to hold good quality videoconferencing from mobile users to home users, over IPv6, in the near future.

It is interesting to note that the huge growth in the popularity of SMS messaging on GSM mobile phones was not foreseen when GSM was deployed. The billions of messages exchanged each month between mobile phone users illustrate the demand for and popularity of peer-to-peer communications.



3.6. *Ambient Intelligence*

The combination of ubiquitous computing, ubiquitous communications and intelligent social user interfaces allows for the implementation of electronic environments that are sensitive and responsive to the presence of people. Those environments should recognize the users and tailor themselves to the needs of the users. They should be adaptive to changes in the environment and be able to anticipate the desires of the users.

An important aspect in these environments are "smart" devices, more and more sensors and actuators will get networked and will be able to participate in intelligent environments. A specific example in this context is networked devices, which use biometric authentication technologies.

The ubiquitous communication part of course is central in this context. Besides the needs with respect to quality of service, security, and mobility, which have been mentioned, already these applications put strong requirements on address space, auto-configuration and dynamic reconfiguration. The document "Scenarios for Ambient Intelligence at 2010" available at http://www.cordis.lu/ist/istag.htm contains detailed scenarios describing possible applications.

3.7. Medical applications

Where communications are required between places and people such as hospitals, ambulances and doctors on the move, an appropriate secure, scalable infrastructure is required. Ipv6 can provide that infrastructure. The 6WINIT (www.6winit.org) 5th Framework project is currently addressing these issues.

3.8. In-car communication

While 3G will deliver advanced mobile services to people on the move, a similar provision should be made for cars. This will enable information to be communicated to the car, e.g. the latest weather information and traffic congestion (information that can be obtained from other networked vehicles near the user). It will enable on-board entertainment, e.g. for children in the back of the vehicle. It will also allow remote fault diagnosis, and fleet management facilities.

There is already a pilot service in Japan where 1,200 taxis have IPv6 connectivity.

4. Conclusions

For next generation applications, we are confronted with a number of challenges:

- Ease of use: no system administrator, auto configuration (discovery & registration), zero administration, easy mass software updates.
- Scalability, up to an Internet of 10 billion nodes or more. The IP protocol must be able to cope, as must core network services such as DNS.
- Interoperability across several heterogeneous networks.
- Safety and security, for which a Public Key Infrastructure (PKI) may be needed.
- Manageable quality of service.
- A lot of devices: the need for (fixed) IP(v6) addresses.
- Mobility
    - Devices across locations and networks,
        - Ad-hoc connections,

    - Transparent hand-off (horizontal and vertical),
    - Adaptation to network characteristics,
    - Auto-configuration (discovery, disconnect)
  - Persons across devices and network,
    - Access to preferences, profiles and rights
    - Adaptation to devices characteristics
    - Devices reservation/sharing
    - Portable sessions
  - Programs across devices,
    - Safe and secure portable code

IPv6 will contribute to a solution for a number of these challenges.

Examples of suggested projects where this should be explored are:

- Using IPv6 as the universal network layer across a mix of heterogeneous networks such as Ethernet, Wireless LAN, Bluetooth, Zigbee, power line and investigate the implications with respect to QoS, auto-configuration, device and service discovery. An important aspect is the development of middleware which allows dynamic (re)-configuration of services based on network and devices characteristics (e.g. the use of transcoders) and the dynamics related to device and service discovery in a changing environment. Standards to exchange this kind of administrative information, negotiation on which services to use and the aspect of reserving devices or services in the future (i.e. to program the recording of broadcasts) are needed.

- The use of peer-to-peer technology in the entertainment and infotainment industry. Peer-to-peer technology to access and manage data in a distributed storage environment will become more and more important, not only for business environments but also in the consumer world. This will increase when consumers are going to capture more and more assets in a digital format. An example is the fast growing market of still image cameras, which can be expected to be followed by digital video recording.

- Remote home control and home security. With the growing application of “smart” sensors and actuators that can be connected to from outside “always on” broadband home networks. Of major importance are the issues related to secure remote access and the small footprint of software in these devices, which could be sprinkled around, as “smart dust”.

- Person centric applications such as multi-media communication. It should be possible to contact a person wherever they are. VoIP in combination with unified messaging applications are a good approach. The requirements for real time audio and video put high demands on the quality of service. The use of SIP to set-up calls offers facilities for selective use of media based on network and terminal characteristics. A special issue is to determine location independent uniform naming scheme for persons.

- Applications in vehicles such as:

    - Driver support by location-aware systems, continuous up-to-date navigation support, traffic management

    - Passenger infotainment services, including location-aware services

    - Logistics and fleet management

- Ambient intelligent environments, smart rooms, smart kitchens, houses or offices

5. Recommendations

The Next Generation Applications Working Group makes the following recommendations:

- Educate all stakeholders targeting infrastructure suppliers like network providers, service provider and equipment vendors addressing the benefits in their specific trade. It is also important to demonstrate that while migration has its cost, failure to migrate to IPv6 in a timely fashion will incur greater costs in the long run.

- Disseminate the IPv6 application opportunities in all kinds of industrial forums and consortia. It should be noted that IPv4 was not designed as an enabler for the Web; the Web emerged many years after the introduction of IPv4. Likewise, the global addressability and features of IPv6 may not be met with an instant “killer application”, but these will follow from the restoration of the original end-to-end principle of the Internet.

- Promote the roll-out of IPv6 products e.g. IPv6 connectivity in consumer-electronic devices by 2005. While not all such devices may be IP-enabled for Internet connectivity, those that are should be IPv6-enabled. Auto-configuration should make home network appliances easy to use; devices that are Internet ready can be expected to be favoured in the marketplace.

- Encourage national governments in Europe to accelerate the roll-out of broadband, always-on networking to homes and small businesses.

- Vendors are encouraged to incorporate IPv6 APIs into their products, e.g. programming language environments and interfaces to, for example, database systems.

- Support projects that explore new applications that take real advantage of the IPv6 features, e.g. remote IP-enabled sensing and monitoring. This will be a new market of innovative application where Europe can have an advantage over the USA and Far East.

- European chip manufacturers are encouraged to develop an "IP chip" (IPv4 and IPv6) to enable IP sensor technologies that promise a raft of next generation applications by 2004. IP connectivity would take the place of other forms of communication (e.g. serial port protocols). One may expect IP-enabled devices to also utilise wireless LAN or Bluetooth media.
- European entertainment vendors are encouraged to develop IP-based games that take advantage of the peer-to-peer networking model for transparent end-to-end IP communication by 2004. Such models reduce the requirement for supporting and managing communal player servers, and allow players to make direct contact.

- European security vendors are encouraged to develop IP-based biometric authentication technologies by 2005 (using voice, fingerprint, face, hand scanning, iris or any combination of these).

- The European education sector is encouraged to introduce video conferencing using end-to-end IPv6 with its mandated multicasting features. The introduction of IPv6 on the GÉANT pan-European academic backbone will aid such applications. The European academic networks can gain valuable early IPv6 deployment experience.

- European car manufacturers are encouraged to deploy and test IPv6 on "Internet Car" prototypes to validate wireless and mobility methods by 2005.

- In view of the widening deployment of VoIP, European telecom vendors are encouraged to develop dual stack SIP phones. The use of IP phones will open up possibilities for new addressing methods, e.g. devices need not be addressed by traditional telephony numbering (alone).

- Companies and organisations procuring software systems or new network hardware should seek to obtain some form of IPv6 “future proofing” statement from their software or hardware systems suppliers.

- An IPv6 “Centre of Excellence” should be established in Europe, whether physical or virtual (with experts across Europe) to develop a European IPv6 open source code base, enabling the more rapid development of novel next generation applications.