1 Publishable summary

1.1 Project Context & Objectives

The European Union (EU) and India have established an extensive cooperation in the science and technology sector. The promotion of IPv6 technology and deployment of next generation Internet based on IPv6 is one of the goals of this cooperation. In this context, 6CHOICE project promotes the IPv6 technology across India and Europe via the educational and research network (NREN) infrastructure in place in both India (ERNET) and Europe (RENATER).
The project has gathered outstanding EU experts in the context of Internet and IPv6 such as Peter Kirstein (UCL) considered one of the pioneers of Internet in Europe, Sathya Rao a senior consultant and CEO at Telscom involved in several IPv6 projects since many years ago, Bernard Tuy involved in dozens of IPv6 initiatives in the french NREN RENATER and Carlos Ralli Ucendo responsible of the first connection of Telefónica Group to IPv6 networks in year 2000 and former coordinator of Euro6IX, the largest IPv6 industrial initiative in EU FP5.

Those key EU key experts had the opportunity to perform a close collaboration with ERNET (Indian NREN), the prestigious IISC (Indian Institute of Technology) and SIFY, one key player in the ISPs arena in India.

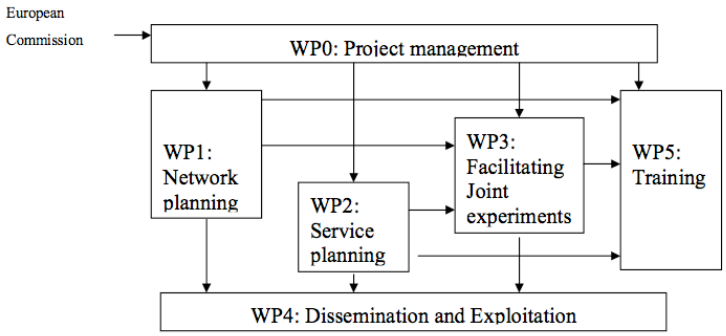
6Choice focussed its activities in "training the trainers", support ERNET-GEANT IPv6 native interconnection and perform experiments to generate traffic across those networks to assess the testbeds and the established connectivity. Additionally, business studies, best practises and dozens of workshops and dissemination events have been performed both in EU and India taking into account the characteristics of each specific reasons.

The following table shows the partners involved in 6CHOICE and the expertise brought by them to the consortium.

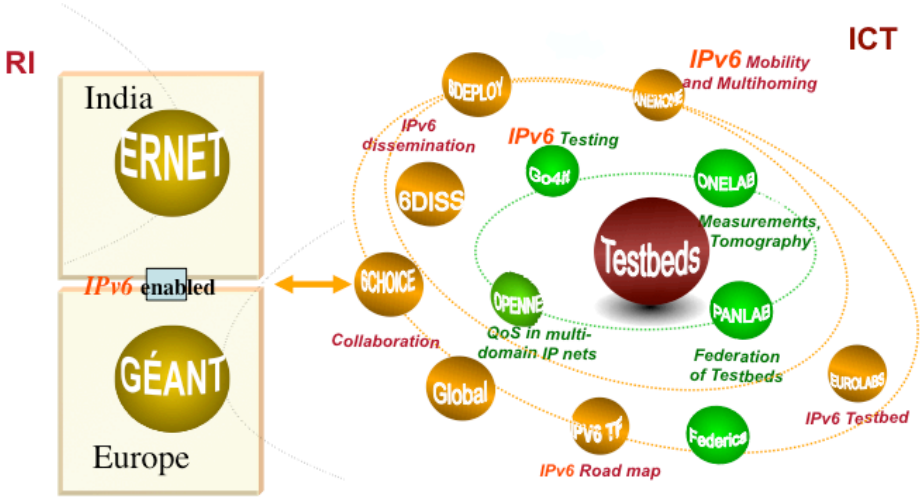
Partner	Country	Type	Primary Expertise
Telscom Consulting	**CH**	SME	**•Coordination and experience in IPv6**
ERNET	**IN**	NREN	**•Network set up and operation**
RENATER	**FR**	NREN	**•Network set up and operation**
Indian Institute of Science	**IN**	University and Research Institute	**•Indian MIT with rich expertise in education and training**
HP	**IN**	Industrial research	**•IPv6 expertise and Applications development**
SIFY	**IN**	Big ISP	**•IPv6 operational experience**
University college of London	**UK**	University	**•Long term research activities in IPv6**
Telfonica I+D	**ES**	ISP+National operator	**• Commercial IPv6 operational experience**

1.2 Description of Work performed & Expected final results

The following diagram depicts the structure of 6CHOICE work packages. This section will focus on the main results of each work package with the exception of the project management (WP0).



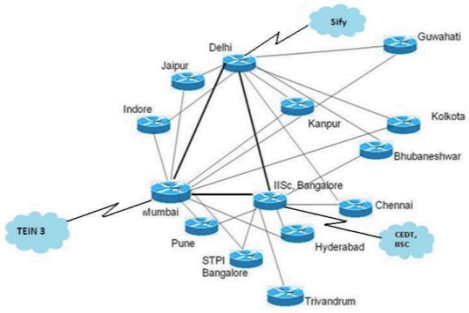
The picture below describes the collaboration framework in terms of NRENs, testbeds and ICT projects where 6CHOICE has lived in. Most of this potential partners have had available 6CHOICE results in EC concertation meetings and this consortium has cooperated to the relevant ones.



The following sections summarize the most outstanding outcome at each WP level but it is not a summary of all main results in each of them. Please refer to D1.4, D2.2, D3.3, D4.1, D4.2 and D5.3 deliverables available at the project website (see section 1.5).

1.2.1 Key Result of WP1: Network Planning

6CHOICE project team performed the necessary support to configure ERNET research network in India IPv6 native POPs and its interconnection with Teint-3 network and thus to GEANT in EU.



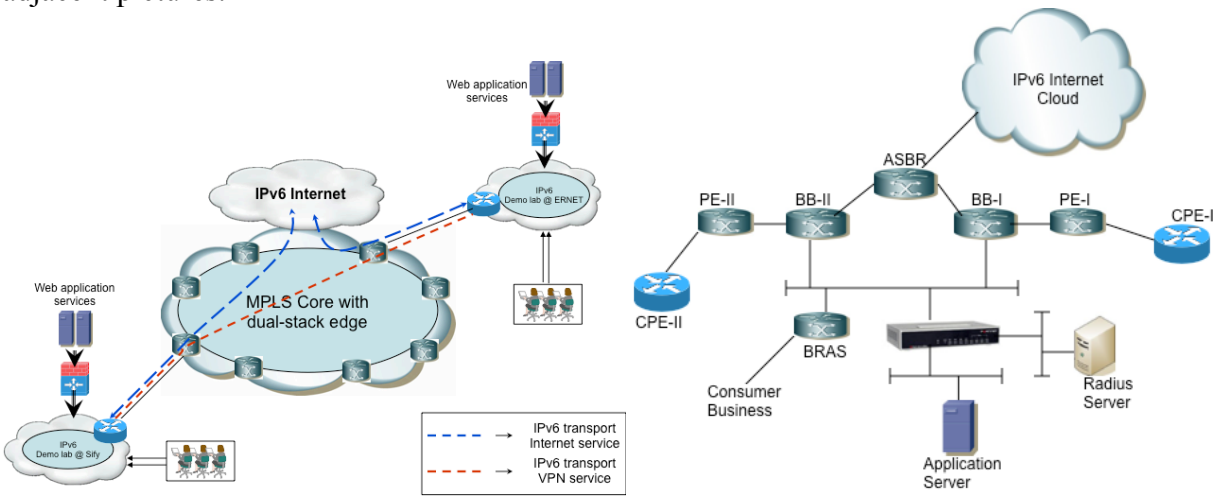
Once interconnected the project deployed tools to assess the interconnection characteristics and perform real-time shared monitoring with tools like MAGALIA and Jperf.

1.2.2 Key Result of WP2: Service Planning

The project team has proposed, executed and refined a six-steps methodology to be followed by organizations interested in migrating to IPv6.

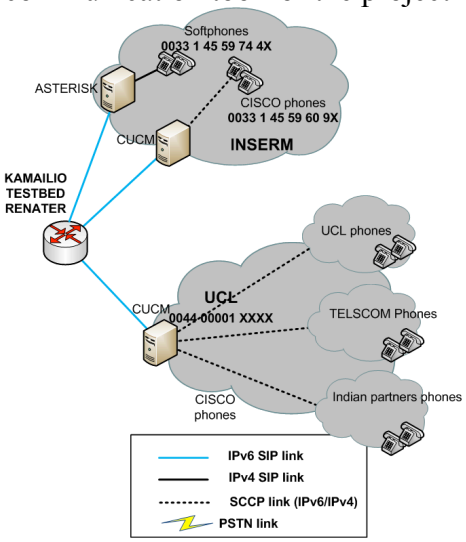
	Step 1 *Addressing*	Step 2 *Routing*	Step 3 *DNS*	Step 4 *Basic Services*	Step 5 *Security*	Step 6 *Monitoring*
RENATER	Done	ISIS and BGP4+	Bind	Web, mail, etc	ACLv6 + Netflowv 9	Nagios, Netflow, weathermaps, H/w probes, etc.
Telefonica I+D	Done (Two /32 prefixes)	Done ISIS & BGP4+	Bind 9	Web, Mail, Audio/Video Streaming, Web Portal, Tunnel Broker	ACL in the routers	Ping Reachability-Delay Statistics, Magalia
Telscom	Done	BGP4	Bind (IPv4/v6)	CUCM, Web, Streaming, Cloud, VLAN, Sensor network, Home environment, ISABEL,..	ACLv6	
UCL	Done	Static	Bind (IPv4/v6)	Web, VoIP, Video-conferencing tools, HEN sensor network	Have not put in ACLs – but could easily	Basic Cisco traffic statistics
ERNET	Done	OSPFv 3 & BGP	Bind(IPv6)	Mail server is set up. IPv6 Portal www.ipv6.ernet.in is up and running.	ACLv6	Magalia was deployed& configured. Cannot provide IPv6-only traffic as ERNET has a pure dual stack without virtual interfaces
IISC	Done	OSPFv 3 & BGP	Using DNS (Bind IPv6) at ERNET-Delhi (2001:e30:1801:1:20c:29ff:feb6:47b5)	ISABEL, CUCM		
SIFY	Done	BGP, MPLS	Bind (IPv6/IPv4)	Web portal, consumer and business internet service	Firewall ,IPS, IDS	SIFY Beacon under testing for fault and performance management using IPv6. Tested IREASONING (a freeware tool) for receiving traps on IPv6.

Additionally, the project team has pointed out the target infrastructure to perform tests and train the trainers on IPv6 deployment. Following the proposed scheme, 6CHOICE Indian partners deployed the IPv6 Demo Lab, with the sponsorship of Cisco Networks, depicted in the following two adjacent pictures.



1.2.3 Key Result of WP3: Facilitating Joint Experiments

The most useful trial was the IPv6 Telephony as it reached enough quality to be used as a regular communication tool for the project management and technical coordination.



The following table describes the details and outcomes of this experiment.

TEST NAME	Telephony over IPv6 (ToIPv6)
COORDINATION	UCL
PARTNERS	UCL, Telcsom, IISC, ERNET, SIFY, RENATER. (TID connected to through the PSTN gateway).
INITIAL GOALS	1. Assess EU&India partners IPv6 interconnection. 2. Enhance telephone communications among partners.
RESULTS	- Used as a project tool for all monthly project call conferences. It

	was successfully used for plenary calls more than 10 times. - Significative cost reduction with acceptable quality. ERNET estimated around 1500 eur savings. - Other partners were connected via PSTN gateway (TID)
NEXT STEPS	Though CUCM is supposed to support Video as well, it was not possible to test, as SW is not yet stable. ERNET will keep infrastructure so communications may be kept after project end with the same numbering scheme.
ACHIEVEMENT	100% (goals 1 and 2)

A second successful outcome was the ideation and detailed description of a new end-user service exploiting IPv6 capabilities and profitable for ISPs. A concrete business model has been generated too. The complete scenario has been developed and deployed at TID Labs and other partners, mainly SIFY Indian ISP has provided feedback to the technical details and business plan.

The following table describes the details and outcomes of this experiment.

TEST NAME	**"Live at me" assessment**
COORDINATION	TID
PARTNERS	- EU: UCL, TID - India: SIFY
INITIAL GOALS	1. Take the TI+D IPv6 multicast streaming service implementation and define a commercial service for IPv6 ISPs including a complete technical description, stakeholders and their benefits and whole business model. 2. Collect feedback from EU & India 6CHOICE partners. Commercial ISPs view is relevant and academic partners are also relevant as a potential service in the context of NRENs (such as GEANT3 & ERNET). 3. Revitalize the platform at TID. 4. Involve one Indian partner to deploy the trial.
RESULTS	- A service brochure with all details has been provided. - A suvey form was distributed and collected to summarize partner's feedback. - TI+D has successfully revitalized the trial in its labs and therefore demos of this service concept are available for further initiatives. - Neither ERNET nor SIFY were finally engaged to deploy the trial due to lack of time for such a task. - The service concept has been disseminated in international conferences and has been provided to ETICS FP7 EU IP project to search models of providers' interconnection enabling interprovider deployment and agreements.
NEXT STEPS	- Interprovider multicast or, at least, interprovider agreements for this specific service would mean an enabler for the idea under study. Some analysis and design work is needed on this regard and, probably work on the related standardization bodies (mainly IETF).
ACHIEVEMENT	75% (1, 2, 3 and not 4)

In the following paragraphs, the service model description is included exactly as it appears in the service public brochure published in the 6CHOICE WEB page.

Live@Me: "What's your show?"

(Technical description: High speed Real-time multimedia data delivery in the cloud)

Service Model

Live@Me is a brand new opportunity based on the cloud computing model for long tale Internet providers to enable home or mobile customers to become live shows producers.

Live@Me allows live content producers to set-up professional radio, TV or data-streaming stations. These producers will establish an open or pre-defined group of listeners or customers & produce real-time contents delivering them as one simple multimedia flow to the network.

With Live@Me, producers don't need expensive servers or broadband connections as they deliver it to the cloud (the Network), which will in turn copy & distribute the content flow to the show subscribers with low record delays and thus making live TV or radio shows a reality. Data-streaming stations or applications requesting the lowest transmission delays, such as emergency networks, might be interested as well.

Live producers might go from regular citizens creating live programs on specific hobbies to live contests, amateur singers or even famous starts answering fans requests.

Live@Me allows the ISP to manage the maximum number of active subscribers to a specific show, depending on the Live producer profile and service agreement. This way it guarantees service quality and keeps network under control.

Technical Overview

In order to achieve easy content flows distribution and the lowest delays the ISP will use Multicast transport at the IP layer. Other techniques used by current solutions based on software platforms processing flows or data messages are subject to bigger delays and congestion on unexpected audience growth or emergency events.

Specifically, Multicast SSM service is selected to enable a specific source to deliver content to a group of subscribed listeners.

As Multicast SSM needs a public IP to deliver the content and NATs or proxies may jeopardize the service deployment, IPv6 SSM Multicast is chosen as the transport/distribution platform for the service.

By default, standard Multicast SSM would allow any potential listener in the network to subscribe to an active source and thus preventing a proper network control and customers differentiation. To avoid this, a modified architecture is defined: a centralized platform keeps a database with the maximum number and nature of potential subscribers and manages the Multicast SSM subscriptions establishing priorities and keeping the number of active subscribers within the agreed broadcasting limit.

Potential subscribers may receive the contents with any of the numerous existing IPv6 multicast SSM enabled clients and a WEB portal will keep information on active open and accessible groups.

Due to the architecture of Multicast SSM and in order to provide a universal service across the Internet a method and platform to establish and implement interprovider agreements is needed. The definition of such method and platform enabling other ISPs to join Live@Me services is beyond the scope of this document.

Business Case

Most ISPs today compete offering flat rate Internet accesses to their customers both at home premises and mobile terminals. Because of this and the decreasing number of potential new customers, added-value services research is key to increase the business growth.

Live@Me is an added value service where flat rate customers willing to become live shows producers pay a monthly fee to deliver their show up to N subscribers. The maximum number of active subscribers (N) establishes the service segmentation:

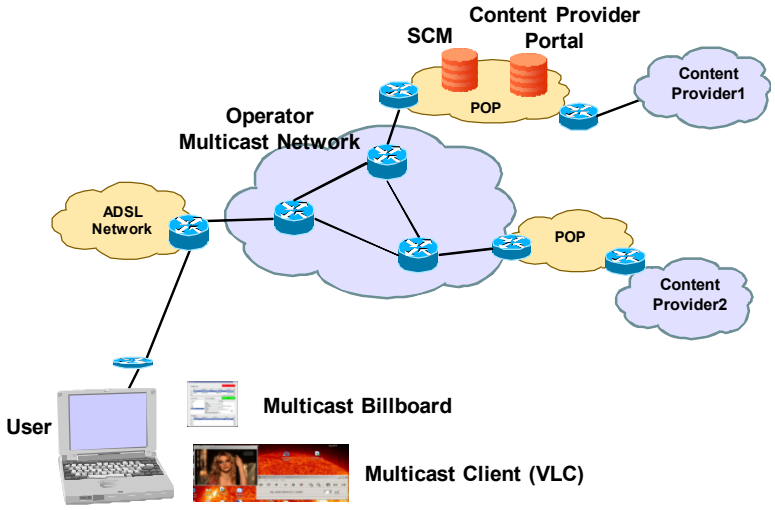
- Producers expecting from 1 to 250 active subscribers at once are not expected to get revenues from their activities and thus a small fixed monthly fee should be charged.
- Producers expecting from 251 to 1000 active subscribers at once might not have direct incomes but benefit from some advertisements/marketing actions and thus expected to pay according to well-defined network usage (traffic sent) levels.
- Producers expecting more than 1001 active subscribers at once may require other specific agreements.

Besides show producers, Live@Me might be interesting for real-time data providers such as weather stations or authorities interested on disseminating emergency alerts where delay and congestion are key parameters. In the later case, Live@Me will not suffer congestion problems of users accessing a WEB page and thus guaranteed-delivery instructions can be delivered to the population. Network can be configured to prioritize such emergency data flows under special conditions or emergency situations.

As an example of the above, there are earthquake early alert systems in Japan exploiting ISPs IPv6 Multicast services. Others examples include IPv6 surveillance cameras systems.

Service Elements & Technical Details

The following diagram shows the service architecture.



Live@Me service means the following service elements and requirements:

1) Last mile IPv6 native multicast

End-users are expected to have IPv6 native access and IPv6 Multicast must be deployed at all IP routers in the access, aggregation and core layers of the ISP.

The standard Multicast SSM subscription mechanism is not used. Access routers are configured to ignore (filter) user subscription datagrams, which are actually forwarded to the service SCM platform.

For a functionality trial, IPv6 tunneled service and IPv6-multicast over IPv6 tunnels might be used but would not show the advantages of the service.

2) SCM

SCM software platform keeps the providers, contents and active subscribers database. SCM also keeps (or has access to) a database so that a specific user can be mapped into a specific interface of the corresponding IP access router.

SCM logic receives end-users subscription datagrams and, once validated, the platform connects to the proper access routers and enforces the corresponding interface subscription. The validation process includes checking maximum number of allowed active subscribers, prioritization of users once more subscribers are not allowed and authentication of subscribers when the show is targeted to a pre-defined group of potential listeners.

3) Content Provider Portal

Being a WEB based platform, it allows the producer to define active shows, announce them in advance, configure open or pre-defined group, define users in pre-defined groups and establish priorities.

While on Live transmission, the portal offers monitoring information such as users subscribed, network usage, etc. It may allow also service upgrade with more potential subscribers at once if a specific show is successful.

4) Multicast Billboard (user terminal)

Users can use any client able to request the reception of IPv6 SSM Multicast flows, such as VLC (http://www.videolan.org) software.

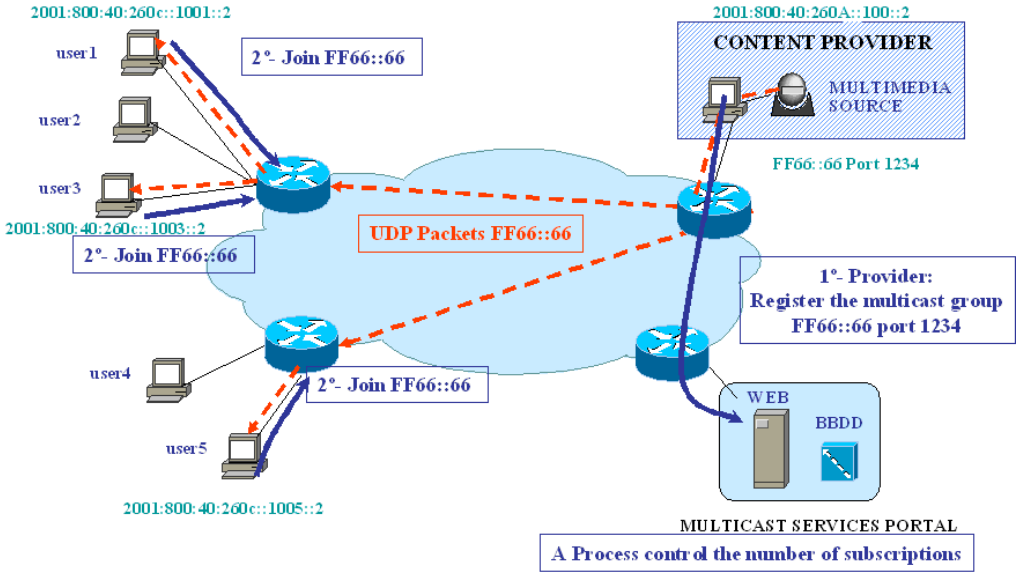
However, a specific client is used at the user terminal to capture subscription datagrams, which are forwarded to the SCM. To enhance this client with more functionality, it connects to the SCM and shows active open or authorized shows to receive (Available Contents from SCMs Multicast group). It can be configured to launch VLC or other viewer when double-clicking one specific show.

The need for this specific client to manage subscription datagrams can be avoided by defining a mechanism in the network to forward (besides filtering) user subscription datagrams to the SCM

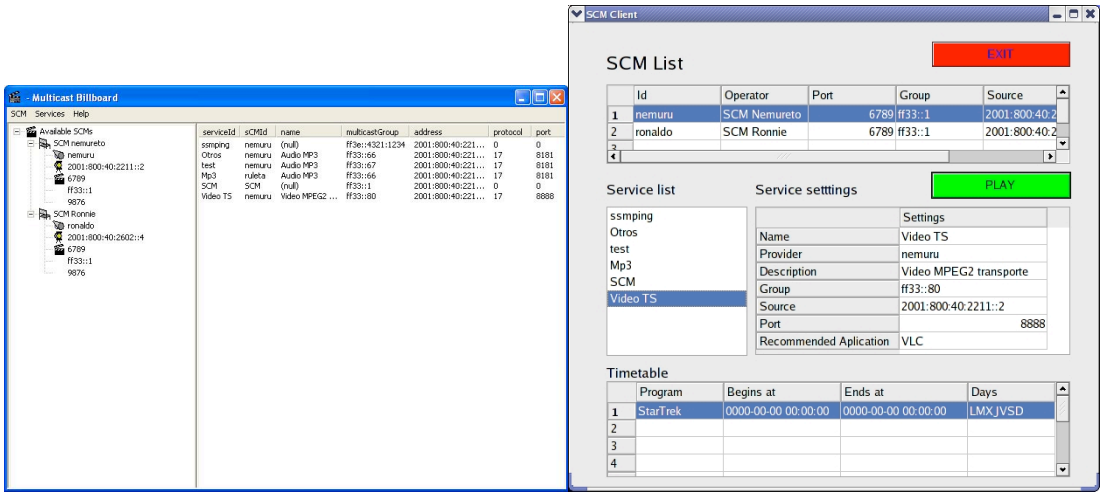
platform. In such architecture, users may access the Portal to monitor existing active shows or data streams. The design of such architecture is beyond the scope of this document.

Service Snapshots

Service Trials realized at Telefónica I+D premises:



Client Snapshots:



1.2.4 Key Result of WP4 & WP5 (Dissemination and Training)

The following tables show the outperforming results on dissemination and training events realized by the consortium team both in India and EU.

Event Title	Location	Dated	Relevance
EGEE08 conference	Istanbul, Turkey	22-26 Sept. 2008	Policies and Sustainability session related to e-infrastructure
Swiss ICT summit	Lugano, Switzerland	10 Oct. 2008	ICT research results including IPv6 for the future Internet. Co-organised by Telscom
6th Concertation meeting	Lyon, France	24th Nov. 2008	Concertation meeting on infrastructure
6CHOICE project meeting with advisory group	Lyon	25-26 Nov. 2008	Planning new and relevant activities
ICT2008- Exhibit	Lyon, France	25-27 Nov. 2008	European event. participation of 6CHOICE with applications and in the networking sessions
Internet Governance Forum (WSIS event)	Hyderabad	3-6 Dec. 2008	IPv6 session organised by 6CHOCE
IPv6 workshops	Several in India Indore Bangalore Pune Kolkata Delhi Bangalore Hyderabad Kolkata Mumbai Kolkata Banglaore Bhubneshwar Jaipur Coimbatore Guwahati	 4-5 Dec. 2008 8-9 Dec. 2008 18 Dec. 2008 11-12 Jan. 2009 28 Jan. 2009 23-25 Mar. 09 26-28 Mar. 09 22 May 2009 25-26 Nov. 2009 20-21 Jan. 2010 9 Feb. 2010 9 April 2010 10 May 2010 17-18 May 2010 27 Aug 2010	IPv6 workshops with agenda addressed to operational staff. Most of these events were held at ERNET PoP locations. They were open workshops for external people and many univ. and engineers from ISPs participated. Each workshop had approximately 50-60 participants.
IPv6 Summit	Bangalore	8-9 Dec. 2008	IPv6 business level summit involving multiple stakeholders
e-infrastructure for distance learning symposium	New Delhi	28-29 Jan. 2009	BELIEF-II and 6CHOICE organised event involving GLOBAL and 6DEPLOY projects, with Indian partners
EC IPv6 workshop	Brussels	23 Mar. 2009	EC level IPv6 strategy discussions with invited participants, including 6CHOICE
IPv6 training event,	Bangalore	17-18 Apr. 09	Training for participants from universities across India
Future Internet Assembly	Prague	May 11-1309	Future Internet and IPv6 discussions
SIFY industrial workshops	Chennai	April '09 May '09 June'09 July'09	Basics of IPv6 IPv6 deployments and Network Migration Cisco - IPv6 Workshop IPv6 deployments and Sify's implementation on IPv6
Global infrastructure event	Distributed event	30.6-1-7.2009	Info day of e-infrastructure with remote participation
National IPv6 workshops	Delhi Bangalore Chennai Mumbai Delhi (ISPs only) Calcutta	21.7.2009 15 Sept. 2009 22 Oct. 2009 27 Nov. 2009 14 Jan. 210 22 Jan. 2010	National discussion workshop with all stakeholders IPv6 applications
E-infrastructure conference	Networking event via ISABEL	1 July 2009	Global e-Infrastructure networking event for distributed infoday from EC
SANOG conference + IPv6 workshop	Chennai	22-24 Jul. 09	SANOG conference + APNIC IPv6 workshop
IISc training event	Bangalore	6-9 Oct.	Organisation of training event to number of invited institutions

IGF2009: International IPv6 workshop	15-18 Nov	Sharm El Sheikh	6CHOICE organised workshop for international participants
IPv6 summit	Delhi	15-16 Dec. 2009	6CHOICE supported national event with applications demo
6CHOICE workshop/training	Bangalore	9-10 Feb. 2010	Workshop and CISCO testbed inauguration
IPv6 testbed opening and demos	Chennai	11 Feb, 2010	IPv6 testbed demonstrated with interconnection to other testbeds
Future Internet	Valencia Spain	14-16 April 10	Understand where IPv6 will fit into future EC programmes
IPv6 workshop	Madrid	30 April 2010	IPv6 transition: business impact and governance issues"
IPv6 workshop	Jaipur	10 May 2010	ERNET PoP workshop
IPv6 workshop	Gauwhati	27 Aug. 2010	IPv6 for technical staff at PoP

1.3 Potential impact, use and exploitation of results

There are three types of actors involved in the 6CHOICE project. Each kind is assigned a specific potential exploitation plan summarizing the per-partner exploitation plans described in the project public deliverables.

- **Telecom operator/ISPs:** Both Telefónica (operates mainly in EU & Latinamerica) and SIFY (India) can benefit from all studies performed, specifically in what regards to IPv4 address consumption and foreseen depletion. Business models and brand new service definitions benefitting for IPv6 (such as the m2m experiments and the multicast "Live@me" example) show the path to leverage RoI from the necessary migration costs ahead. In this line, Telefonica has plans to deploy IPv6 in the framework of 2011-2013 and will keep on exploring potential applications and business models.
- **National Educational and Research Network (NREN):** The interconnection of India and EU networks using native IPv6 opens a wide road to explore new applications and protocols demanding and exploiting end-to-end connectivity and other features of the forthcoming IPv6-Internet.
- **Consultancy Companies:** Companies like Telscom will exploit the knowledge and experience acquired during the project lifetime to provide consultancy services to bigger companies demanding expertise and support.
- **Third Parties outside 6CHOICE Consortium:** Public deliverables describing the methodology for migration, business considerations, characteristics of both regions regarding IPv6 deployment and trials and new fields to explore with IPv6 will be indeed quite useful for organizations interested on both regions advances on IPv6. The present report might be useful as well as a brief summary of project results.

1.4 Project Public Website

The project started on Mar 1st 2008. The domain name “www.6choice.eu” was registered for the on-line dissemination of the project results. The original design of this website for easy navigation was developed. The project logo was developed to show the linkage between Europe and India, through the usage of national flags and stars.

The screenshot of the web home page is depicted below (figure 1), showing the main menu list to be guided through different content levels.

Under the publications all public deliverables, presentations and press release documents are available for download. The standards/links menu will lead to the IETF specifications published and links to number of projects that are active in promoting IPv6. FAQs menu will provide IPv6 resources (how to...) for implementing IPv6 networks and applications to the newcomers to the field. Registered members can feed the important news to the website visitors at any time. Helpdesk facility is extended through contacts available from the website. A private webspace/FTP is also available to the partners for project level communications.