UNIVERSIDAD CARLOS III DE MADRID, Dpto. de Ingeniería Telemática

XXVII CONVOCATORIA DE PREMIOS "Ingenieros de Telecomunicación"

Tesis Doctoral

Contribución al Desarrollo de Soluciones Para la Integración de Métodos de Establecimiento de Sesión en Redes 4G

(Contribution to Designing Suitable Session Setup Solutions in 4G Networks)

Autor: D. Antonio Cuevas Casado
Director: Dr. José Ignacio Moreno Novella

Leganés, julio de 2006

INDICE

Esta tesis obtuvo la "mención europea"; siguiendo la normativa, hubo que redactar partes de ella en un idioma extranjero, en nuestro caso el inglés. Tras consultar con el Colegio y, para reflejar más fielmente los contenidos de la tesis, el resumen aquí presentado también incluye partes en ingles.

Hemos divido nuestro resumen en los cuatro apartados indicados en la convocatoria de los premios. La bibliografía que consultamos, se encuentra en el ejemplar de la tesis entregado.

1. Objetivos, desarrollo aportaciones y conclusiones de la tesis

We are witnessing a major **change in telecommunications**. The convergence or, better, migration of the telephone network into the Internet is becoming a reality. It is already common to use, over the Internet, traditional services from the telephone network like voice calls. For instance, in 2006, the German journals announced that the Deutsche Telekom cellular clients in Germany can connect to the internet and use the Skype application to do their voice calls via the internet and not via the cellular telephone network.

We believe that two are the **motivations** that are driving this change. First, it will **spare costs** to the network operators since, instead of managing two different networks, they will need to handle one single network. Second, it will **increase revenue** since, due to the open characteristic of the Internet, it is very easy to build more and better services upon it and to offer them to the users who will then expend more money.

Network operators such as NTT are already driving their efforts to this convergence. In the research filed and even in the commercial world, many other approaches and ideas exist. This exciting and hot research area is known under the generic term of "**Next Generation (or 4th) networks**". The definition of 4G network is still vague but it is clear that it will be a step beyond the 3G "All-IP" based networks in the sense that IP will be native in 4G networks while it is an "overlay" in 3G "All-IP" ones. Apart from this technological **migration** to an only IP networks, 4G networks are also characterised by new "**converged**" business models.

But this **change is full of challenges**. First, the services offered today in mobile and fixed telephone networks should be moved -with the same or better performance- to the Internet. This is far from being simple due to the very different **technical** natures of the telephone and the Internet networks. On the other hand, **business-related** aspects pose also serious constraints to this convergence. For instance, although the above mentioned openness of the Internet is positively seen as a source for increased revenue, networks operators fear to loose their central role in the provision of services, particularly in telephony or SMS services. If care is not taken the network operators may become mere "bit pipes". For instance, in Europe, it is estimated that Internet telephony has diminished by 25% the revenues of traditional telephone network operators".

Migration is already happening, it can not be avoided and, besides, the networks operators should profit from this migration. But there are a lot of **uncertainties** on how to make this migration something positive.

Because of this and the lack of "winning" business models, proper **session setu**p and management **solutions** integrating service and network layers **are not yet available**. This thesis **tackles this** issue. Our aim is to design solutions that place again the network operator in the core of the business value chain. IMS or i-mode business models will be followed.

It is true that **available solutions** partially cover these aspects. Among them is the SIP (Session Initiation Protocol) which is widely used. With SIP, two users can agree on the characteristics (like codecs) of the (multimedia) session there are going to share. There are also protocols to setup sessions at "data transport" level, for instance RSVP (Resource Reservation Protocol). But there is not yet a clear way to integrate both into a common framework taking into account issues such as users' profiles or tariffs and with characteristics like single sing-on.

This lack of solutions is due certainly to the fact that we need to **negotiate** at **two** different **levels**: **service and transport** and that the **business entities** offering the service and the transport may be **different**. This is a key issue in the development of 4G networks and, in the session setup aspect, it is of special relevance. This **integration** between service and transport **in session setup is**, among others, one of the **key** points the network operators have **to** achieve to **be** in the **core** of the value chain of the **telecommunications business**. However, as we showed, we can not go back to classical telephone network model, where transport and service are combined. It is just the opposite, we must go to an Internet like model where transport and service are separated but defining the correct interaction between them.

The objective of this thesis is to contribute to designing suitable **session setup** solutions in 4G networks **integrating** both **application and network layer** aspects and services. Integrating those aspects in session setup implies, actually, to integrate the applications and the network transport services. Our challenge is that the **Internet model** of complete separation between transport and applications will be **kept**. Our solutions will position the network operator in the core of business chain, thus giving an answer to the urgent needs just presented.

This thesis will **concentrate on** the **orchestration between the different systems, sub-services and business entities** and supporting in an integrated framework several scenarios and business models. To do so, several aspects need to be covered. Those include signalling, handling of user profiles, division of tasks and functionality, etc. All this will be done in our proposed 4G framework. The **goal** is to **build a service platform** open enough to offer any kind of service, it must offer them with the best quality and yet it must be simple enough to require few managing cost from the operator. These services should be enticing for users who then will employ this operator-controlled platform instead of stand-alone services widespread in the internet having no partnership with the network operator.

The main milestones of this thesis could be:

- Analysis and enhancement of the existing session setup protocols.
- Analysis of 3GPP's IMS as a source for solutions and identify its shortcomings and how to migrate it to 4G networks
- Analysis of 4G networks architectures, profit available solutions, design the needed aspects and provide an architecture to support our solutions
- Discussion and integration of different business models. Design the session setup. Propose the signalling and orchestration between the systems.

- Evaluate the different scenarios and proposals, including by means of simulation

Part of the research done in this thesis has been carried out under large IST projects like Moby Dick and Daidalos, where the author had a relevant role. Rich interchange of ideas could there be done, and some of the original results of this thesis where adopted by these projects.

To meet or objectives, we first undertook a deep **state-of-the art analysis** identifying **research opportunities** but also **profitable solutions**. We found that much work has been carried out in the research fields related to this thesis and that, even, some of the solutions are standardized and have great commercial acceptance (e.g. SIP). However there is not a "glue" integrating all this in a 4G framework. We saw that, for 3G networks, the 3GPP-defined IMS framework integrates some of these solutions under a coherent "umbrella" and achieves a business model that places the network operator in the core of the business value chain. But we identified some issues that need to be enhanced in order to make the IMS solution profitable for 4G networks. Those were mainly the support of native IP networks with any access technology (and not only CDMA) and allowing the coexistence of several scenarios and business models under a single framework. This thesis overcomes these problems.

We focused on the session concept and identified the several **actors** that can create or manage **sessions**. Those were the users, the service providers, the "mediators" (e.g. SIP proxies) and the network provider. The network provider itself can deal with sessions in several ways: its transport system will create QoS-enabled transport sessions, its AAA system will centralize all the sessions created by all the actors (semi-walled garden business model) and we also considered network access sessions.

We showed the advantages of c**onsidering QoS-enabled data transport as another service** and not as a service parameter like IMS does. As *Deutsche Telekom* President said, in the future data transport won't longer be a commodity, it will need to be "differentiated". Our proposal allows the fine control this scenario requires. It eases the network operator in managing the QoS-enabled data transport and all the components interworking to build the final service. In the scenario forecasted by Deutsche Telekom President, there are some issues to solve respect to differentiated QoS-enabled data transport. For instance, users like simple tariffs (e.g. flat-rates) and we must avoid situations like: "streaming news services with discount from 21:00 to 8:00 that uses AF11 transport service with discount from 22:00 to 9:00." In such a case the medium user will not understand how much does he pays. We must also find ways to determine the final QoS to give to a session (e.g. audio call) between two users with different profiles stating different quality preferences. The thesis proposals coped with these issues.

First we must note that, as a service, data transport may be priced and depend on user's profiles, and this will influence session setup techniques, like Figure 1 illustrates.

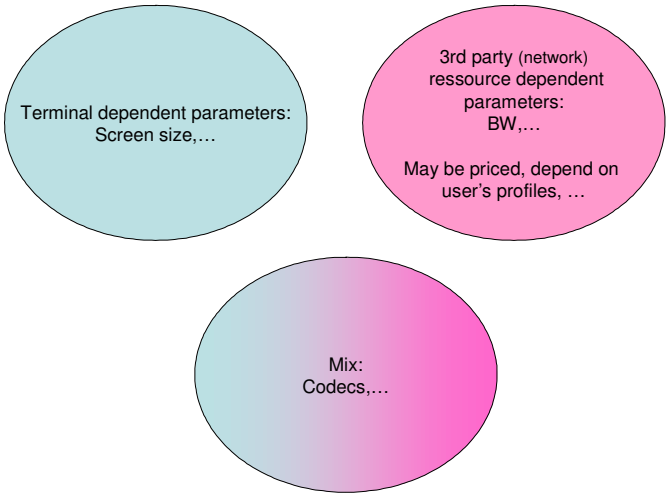

Figure 1 data transport may be priced and influence the session setup negotiation

We proposed to include **cost sharing** aspects in the **session description languages**. This allows the peers to better negotiate sessions in scenarios where the QoS enabled data transport is to be paid and as such is an important piece to help solving the problems above presented.

Other aspects were also addressed to enhance existing session setup techniques such as including preference levels in the negotiated configurations. We saw the advantages of doing so, **speeding** the whole **session setup** process.

These improved session setup techniques was one of the objectives of this thesis. We will see next how our further proposals benefit from these achievements.

Our session setup solutions and the scenarios they enable are to be supported by 4G networks. We analyzed existing 4G networks architectures, identified their gaps and designed an infrastructure capable of hosting our solutions. We evaluated such an infrastructure including **test bed measurements** and integrating aspects such as QoS and mobility. This was one of our main objectives. To design our service platform, we concentrated on three systems MMSP (SIP Proxies), QoS enabled data transport, AAA and the interfaces between the network operator and the service providers. IMS was a good source for ideas.

Scalability was one of the main concerns and we followed the idea of "pushing" finer control to the network edges closest to the users –access networks (ANs)-. This approach is "common", for instance it is followed in IMS; we shall see our contributions and how we take advantage of this "tactic". Figure 2 gives an idea of our proposed architecture for a 4G domain.

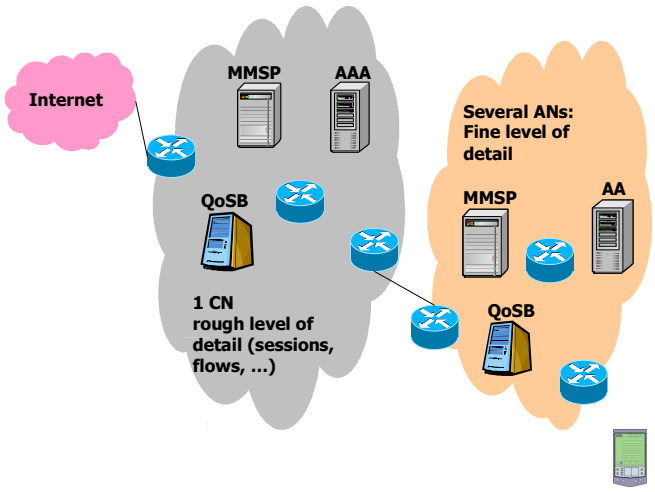

Figure 2 4G designed architecture spanning 3 systems: QoS, AAA and MMSP

The interfaces between the systems (MMSP, AAA and QoS) where pushed to the ANs. The nodes in the ANs had autonomy to take some decisions not involving the nodes centralizing user and service management, located in the CN (core network). For instance, thanks to SAML and transferring user profiles, we could delegate Authorization and Accounting to the servers present in the AN. This **decentralization of the AAA system** is key to allow scalability. QoS-enabled data transport complexity was also pushed to the ANs following the "classical" IntServ and DiffServ interworking or, more accurately, employing DiffServ in the CN with per flow access control in the ANs. We proposed to do this **access control** not only for "upstream packets" but **also for the packets directed to the terminals**. That way we better "track" the flows despite having a scalable DiffServ CN.

We suggested the AN's **QoS Broker**'s role to be more than a policy decision point (like the IMS' PDF is). QoS Broker should handle all the data transport service within their AN, keeping state of the flows. That way the interaction between the QoSBroker and the MMSP or the service providers is **richer than in IMS** and we saw how to take advantage of this. A clear scenario is adapting to changes in network conditions because the user hands over to a less performing access network. We showed how to involve Content Adaptation nodes or change the communication codecs in such a scenario. Note that the IMS can do so, but only at the session setup, not while the session is running.

The interfaces from the network operator (AAA server and QoS Broker) to the service providers were designed supporting several possible scenarios in function of the type of agreement between the network and service providers.

We found that a key to support more interactions scenarios between service providers, users, and network providers' AAA, QoS-enabled transport and MMSP systems was designing an interaction between QoS and AAA. Since we are considering QoS-enabled transport system as another service, this QoS to AAA interaction is necessary to provide this service with AAA capabilities. This **QoS-AAA interaction** was one of our main **contributions** in **refining** current **4G** architectures. The idea is to treat QoS enabled data transport as any other service requesting AAA services and specializing the AAA system in user control and the QoS system in network control, as Figure 3 shows.

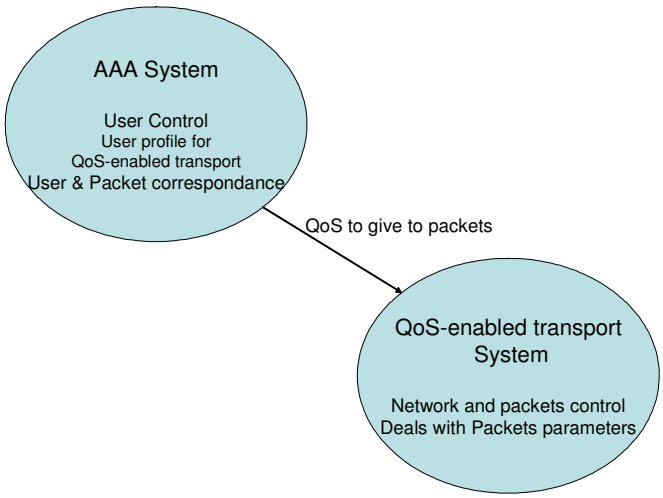

Figure 3 AAA and QoS-enabled transport service interaction

A unified format of AAA infrastructure and services interaction was proposed using **SAML** and the possibilities of distributing user profiles or just authorization decisions analyzed and found the best outcome for the different scenarios. Aspects like **single sign-on and unified billing** are supported in our design.

We achieved **coherence** in the **session(s)** and still coped with **heterogeneity** in QoS-enabled **transport** session setup. For instance, scenarios where one peer uses RSVP as transport session setup protocol and the other peer asks the AN-MMSP to setup the QoS session, have been addressed. Again, this widens the applicability of our proposal. We always bear in mind scalability concerns in our suggested solutions.

Evaluation of our architecture and of our different proposals was one of our main objectives and was addressed in this thesis. The evaluation criteria have included aspects such as scalability or user's privacy. In some issues we have resorted to **simulation** results and we have proposed a methodology to cope with some planning challenges that may appear in future 4G networks with many interacting nodes with different characteristics (such as processing speed). Aspects such as bottlenecks could be identified in our ns2 simulation model and the possible methods to cope with them were suggested and evaluated.

Fulfilling all our objectives and sub-objectives has lead to a complete integrated architecture supporting several possibilities for different scenarios in session setup. The "semi walled garden" business model has been followed while pure "Internet" model applications are also supported, as it was our aim. The integration of several scenarios and business models under a single, coherent framework is one of our major achievements compared to IMS.

2. Originalidad del trabajo

Parte del trabajo de esta tesis se desarrollo en el seno de dos importantes proyectos europeos Moby Dick y Daidalos, donde el autor jugó un papel relevante y muchos de los resultados originales de esta tesis fueron adoptados por estos proyectos.

En esta tesis analizamos el contexto de gran cambio que están sufriendo las telecomunicaciones en la actualidad e identificamos la problemática ligada a este cambio. Dentro de esa problemática buscamos en qué aspectos podíamos contribuir, encontramos "huecos" que, además, se interrelacionaban y daban lugar a una clara línea de investigación. Es ahí dónde elegimos aportar ahí nuestras ideas. Estas ideas han sido relatadas ya y sus beneficios se ensalzarán en el siguiente apartado. Aquí nos centramos en su originalidad.

Nuestra tesis es original en su planteamiento respecto a otros trabajos del ramo, puesto que no sólo se centra en un aspecto tecnológico sino que lo enfoca y lo relaciona con la gran revolución en el plano de negocio que están sufriendo las telecomunicaciones, ocupando los aspectos de modelos de negocio parte destacada dentro de nuestra tesis.

De nuevo resaltamos la principal contribución de esta tesis, diseñar y evaluar una plataforma de servicios que, como principal característica y novedad, permite integrar distintos escenarios y modelos de negocio. Para lograr esto, tuvimos que tratar muchos temas y no sólo nuestras principales contribuciones son originales sino que en muchos aspectos hemos sido pioneros.

Fuimos pioneros en aspectos tales como diseñar, implementar y evaluar (con medidas de campo) redes 4G integrando múltiples aspectos. Nadie antes había diseñado y, mucho menos aún, presentado prototipos con resultados tan satisfactorios y, sobre todo, integrando múltiples aspectos como movilidad, AAA, QoS y todo esto en un entorno inter-tecnología: Cableada –Ethernet- o inalámbrica (CDMA y WiFi). En resumen, logramos hace años lo que ahora está tan de moda: "convergencia fijo móvil" y con aspectos que, aún hoy, son novedosos. Como veremos, estos resultados han llevado a publicaciones en revistas relevantes.

Otros aspectos que han contribuido a lograr nuestros objetivos y donde hemos sido pioneros han sido, por ejemplo, el uso de SAML dentro del marco de AAA y DIAMETER. Hemos explicado las ventajas, desde ser clave para descentralizar el sistema AAA como dar la posibilidad de mejorar los procesos soportados por DIAMETER. Respecto a esto último, conseguimos tanto escenarios de autorización como de distribución de perfiles y delegación de la misma. Estos escenarios posibilitan más tipos de relaciones de negocio entre los distintos actores (usuarios, operador de red, proveedores de servicio).

Las descentralización del sistema de AAA es un hito importante por si mismo ya que innova respecto a la arquitectura planteada por el IRTF/IETF y mejora la escalabilidad. Esta aportación es clave pues, en redes que sigan un modelo de negocio "semi walled garden", el sistema AAA del operador centralizará todas las sesiones y, por lo tanto, su escalabilidad es fundamental. Como hemos explicado, esta descentralización está basada en delegación de responsabilidad usando las características que aporta SAML.

También hemos tratado aspectos desde puntos de vista que nadie se había planteado como, por ejemplo, tratar el transporte de datos como otro servicio. Hemos analizado las ventajas de este novedoso enfoque y cómo llevarlo a cabo.

Otra de las contribuciones originales de esta tesis es definir un interfaz entre el sistema AAA (del operador) y el servicio de transporte de datos. Este interfaz no está presente en otras arquitecturas como IMS y hemos visto las ventajas que aporta.

Aprovechamos mecanismos existentes pero dándoles un uso original empleándolos en aspectos novedosos. Por ejemplo, propusimos que el control de acceso que se hace en redes DiffServ para los paquetes que el usuario envía, se hiciera también para los paquetes que éste recibe. Analizamos en la tesis las ventajas de esta aproximación que contribuye a hacer más escalable la red. Esto es porque logramos un equilibrio entre no "controlar" los flujos en toda la red y mantener un seguimiento suficiente de ellos.

Respecto al modelo que creamos para hacer nuestras simulaciones en ns2 y que nos sirvieron para evaluar nuestras propuestas, resaltamos aquí que, que nosotros sepamos, somos los primeros en crear un modelo de simulación tan completo incluyendo aspectos de AAA, QoS y provisión de servicios. Dicho modelo puede ser útil para IMS.

Hemos mejorado e innovado en otros aspectos, y estas contribuciones y las antes descritas, han logrado, como hemos dicho crear una plataforma de servicios novedosa y que soporte múltiples escenarios.

3. Resultados obtenidos, indicadores de calidad

En los siguientes párrafos resumiremos los principales indicadores de la excelencia del trabajo desarrollado en esta tesis doctoral.

Primero mencionamos que la tesis obtuvo la mención Europa y el tribunal formados por expertos de todo el continente, le otorgó la máxima calificación: "Sobresaliente Cum Laude".

Otro indicador importante de la calidad de esta tesis son las publicaciones logradas, resumidas en la siguiente tabla:

Publicación	Internacionales	Nacionales
Libros	2	
Revistas	4	
Congresos	8	5

De entre las publicaciones en revista, por su significativo **índice de impacto** (JCI) y relevancia destacamos las siguientes:

- **"IEEE Communications Magazine"** Vol 44, N8, Agosto 2006. **Special Issue** "Advances in Service Platform Technologies for Next Generation Mobile Systems". Nuestro artículo se selecciono, después de dos rondas de revisión, entre más de 55, publicándose 12, en dos números de la revista, el nuestro en el primero. Cabe destacar que la revista se sitúa entre las 5 primeras en el área de *Telecommunications*, siendo la revista principal del IEEE Communications Society.
- **"Journal of Communications and Networks"** Vol 7, N2, Junio 2005. **Special Issue "**Towards the Next Generation Mobile Communications". Nuestro artículo se selección después de pasar por dos rondas de revisión.
- **"Computer Communications"** Vol 28, N9, Junio 2005. El proceso de selección incluyo dos tandas de revisión.

Nuestras propuestas se publicaron también en numerosos congresos, principalmente auspiciados por el IEEE, y obtenido en uno de ellos el **premio** a la mejor ponencia, Telecom I+D 2002.

El autor también ha participado en dos libros internacionales escribiendo capítulos relacionados con su experiencia conseguida realizando esta tesis. En concreto estos son:

- "Encyclopedia of Wireless and Mobile Communications"
  CRC Press, Taylor & Francis Group,
  ISBN 978-1420-04326-6
  Pendiente de publicación
  Capítulo "Architectures for Transmitting Multimedia Content Over 4G Mobile Systems"

- "Resource Management in Satellite Networks Optimization and Cross-Layer Design"
  Springer
  ISBN: 978-0-387-36897-9
  May 2007
  Capítulo "QoS Requirements for Multimedia Services"
  Capítulo "Ressource Management and Network Layer"

Además, debemos mencionar que tenemos un artículo en el IEEE Communications Magazine pendiente de segunda revisión y otras publicaciones preparadas.

Destacamos también que el autor ha participación en **proyectos internacionales** donde el autor gozó de un rico intercambio de ideas y muchos de los resultados de la tesis han sido adoptados por éstos proyectos. El autor participó en el proyecto **Moby Dick** (IST-2000-25394), proyecto que contaba con 12 socios y nuestra universidad disponía de un presupuesto de 364 977 €. El proyecto integró la interacción AAA-QoS, una versión más evolucionada se implementó en el proyecto **Daidalos** (FP6-2002-IST-1-506997). En este proyecto participaban 42 socios y contamos en nuestra universidad con 413 847.66 €. En ese proyecto, el autor, además, fue **líder** de la tarea "QoS session setup in 4G networks". Los distintos escenarios y posibilidades recogidas en esta tesis se reflejaron en dicho proyecto además de servir como marco para la interacción con la actividad "Mutimedia Service Provisioning Platform". El proyecto Daidalos también adoptó las simulaciones realizadas en esta tesis.

Además de en los dos proyectos anteriores, se han dirigido cuatro **PFCs.** Dos de ellos se realizaron en colaboración con Ericsson España y un tercero fue co-tutorizado con la universidad de Reading, Gran Bretaña. En estos PFCs se implementaron prototipos para la validación de los mecanismos propuestos en esta tesis. También se realizaron modelos de simulación. Otros aspectos cubiertos fue el estudio de las soluciones comerciales más ligadas con esta tesis.

Los conocimientos adquiridos por el autor gracias a la realización de esta tesis y las principales contribuciones han sido expuestos en **cursos de verano y seminarios** por invitación, como el organizado por VTT en Oulu, Finlandia, ante más de 40 profesionales del ámbito de las redes 4G.

El título de doctor obtuvo la **mención Europea** y se realizó una estancia en los laboratorios de investigación "**Deutsche Telekom**" en Berlin, consiguiendo un fructífero intercambio de ideas dentro de uno de los operadores de telecomunicaciones más importantes del mundo. Entre otros logros, se publicó un artículo al IEEE Internacional Conference on Networks, septiembre de 2006.

4. Aplicabilidad de nuestras propuestas

The technological and business transformations in the telecommunication's world is, in some aspects, so quick that network operators are overwhelmed by the situation. This thesis proposes a framework for the operators to harness and take profit of this situation. These results will be critical to the deployment of 4G and IPv6 networks. Building a 4G and, specially, the access network infrastructure (e.g. TD-CDMA or HSDPA) requires heavy investments that network operators won't assume unless they obtain the key role in the telecommunication market. Our thesis proposes a framework to allow that.

Since this thesis addresses both technological and business aspects is target audience is wide, from next generation network designers to strategic business planners. Besides, the aspects we develop, are hot topics both in the research and industry worlds. IMS, for example, has been adopted by Holland's KPN, Spanish Telefónica is to support its triple pay service using IMS, Orange is pushing fro fixed-mobile convergence vendors like Motorola or Ericsson are struggling to become the lead providers for IMS and NGN products. Still, there are very few skilled people in this area and a lot of confusion in terms like NGN, mobility, convergence, migration that became buzzwords. This thesis addresses and clarifies all these issues.

We saw in the first section of this document how necessary it was to build a next-generation service platform integrating several business scenarios. We saw how current solutions fail to do completely so and presented our proposals achieving a solution that allows network operators to support, under a single infrastructure, a bunch of service models. We support the semi-walled garden business models for a variety of services thus achieving the goals of the 3GPP which is trying to integrate IMS and OSA service-scopes. And the possible relationships between network operator, service providers and users are far richer than in current architectures. Thus, our solution widens the market cases a network operator con offer under its umbrella.

Despite our new proposals, we tried to use standard open IETF protocols that are likely to be employed in NGN and we designed the modifications and interactions needed. That way, our solutions can be implemented more easily, and this is necessary due to the urgent of having service platforms like ours.

In our world, user preference determines all the aspects in the business. For instance, since users prefer and are willing to pay more for direct flights rather than stop flights, the former are more expensive although they generate fewer costs to the airline. All our proposed infrastructure and business models are not an exception. They will succeed if users find any advantage employing the services enabled by our framework compared to applications that just use the network provider as a bit pipe. These advantages are richer and better services and this thesis' proposals create a very good platform to provide them. Still these services have to be found. But the advantage can also be cost sparing. In such a case the question is whether the networks operators will build such an infrastructure just to compete in price. They may do so, since that way they control better the customer relationship. Taking these two aspects into account, we forecast that the solutions here presented or similar ones will be adopted in the future 4G networks.

5. Anexo: Lista de publicaciones

Book Chapters

- "Encyclopedia of Wireless and Mobile Communications"
CRC Press, Taylor & Francis Group
ISBN 978-1420-04326-6
"Architectures for Transmitting Multimedia Content Over 4G Mobile Systems" Chapter
Antonio Cuevas, José Ignacio Moreno

- "Resource Management in Satellite Networks Optimization and Cross-Layer Design"
Springer
May 2007
ISBN: 978-0-387-36897-9
"QoS Requirements for Multimedia Services" Chapter
"Resource Management and Network Layer" Chapter
Antonio Cuevas and others

Papers in Magazines

- "The IMS Service Platform: A Solution for Next Generation Network Operators to Be More Than Bit Pipes"
Antonio Cuevas, Jose I. Moreno, Pablo Vidales, Hans Einsiedler,
IEEE Communications Magazine, ISSN 0163-6804
Vol. 44, No. 8, August 2006.

- "Soporte de QoS en Redes de 4º Generación"
Carlos Garcia, Antonio Cuevas, Jose I. Moreno, Ignacio Soto, Carlos Jesus Bernardos, Pablo Serrano.
Revista IEEE America Latina, ISSN 1548-0992,
Volume 4, Issue 1, March 2006

- "Usability and Evaluation of a Deployed 4G Network Prototype"
Antonio Cuevas, Pablo Serrano, Jose I. Moreno, Carlos J. Bernardos, Juergen Jahnert, Rui L. Aguiar, Victor Marques.
Journal of Communications and Networks, ISSN 1229-2370,
Volume 7, Number 2, June 2005

- "Moby Dick: A Pure-IP 4G Architecture"

Juergen Jaehnert, Jie Zhou, Rui L. Aguiar, Victor Marques, Michelle Wetterwald, Eric Melin, Jose I. Moreno, Antonio Cuevas Casado, Marco Liebsch, Ralf Schmitz, Piotr Pacyna, Telemaco Melia, Pascal Kurtansky, Hasan, Davinder Singh, Sebastian Zander, Hans Einsiedler, Burkhard Stiller.
Computer Communications. Elsevier. ISSN: 0140-3664.
Computer Communications Vol 28/9 pp 1014-1027

Papers in Congresses (full list)

- "Los pilares de las redes 4G: QoS, AAA y Movilidad"
Antonio Cuevas Casado, Carlos Garcia, Jose Ignacio Moreno, Ignacio Soto,
TelecomI+D 2002,
Madrid, Spain,
November 19th, 2002.
Awarded best paper prize in the area of Networking

- "A Simple QoS service provision framework for beyond 3rd generation scenarios"
Victor Marques, Rui L. Aguiar, Antonio Cuevas Casado, Jose Ignacio Moreno, Nesrine Chaher
10th International Conference on Telecommunications ICT'2003,
Papeete, French Polynesia,
February 23-28, 2003.
ISBN: 0-7803-7662-5

- "Mechanisms for AAA and QoS Interaction"
Antonio Cuevas Jose Ignacio Moreno, Rui Aguiar, Victor Marques, Carlos Garcia, Ignacio Soto
3rd Workshop on Application and Services in Wireless Networks,
Bern, Switzerland,
July 2003,
ISBN: 3-9522719-0-X.

- "QoS en Redes Móviles de Cuarta Generación",
Carlos Garcia, Pedro Antonio Vico, Antonio Cuevas, Ignacio Soto, Jose Ignacio Moreno,
JITEL 2003,
Gran Canaria,
September 2003.
ISBN: 84-96131-38-6

- "Servicios de Valor Añadido en Redes Moviles Ad-hoc"
Ivan Vidal, Carlos Garcia, Ignacio Soto, Jose Ignacio Moreno
Telecom I+D 2004.
Madrid

- "Extension of AAA for Future IP Networks"

Pascal Kurtansky, Hasan, Burkhard Stiller, Davinder Singh, Sebastian Zander, Antonio Cuevas, Juergen Jahnert, Jie Zhou
IEEE Wireless Communications and Networking Conference 2004.
21-25 March 2004.
Atlanta. USA.
ISBN 0-7803-8344-3.

- "Field Evaluation of a 4G True-IP network"

Antonio Cuevas, Pablo Serrano, Carlos J. Bernardos, Jose I. Moreno, Juergen Jaehnert, Hyung-Woo Kim, Jie Zhou, Diogo Gomes, Pedro Gonzalves, Rui L. Aguiar
IST MOBILE SUMMIT 2004
Lyon, FRANCE

- "Using CIM Extensions to model Managed Entities in Heterogeneous Network",

W. Dziunikowskiciech, J. Wszolek, P. Gonçalves, S. Rasmussen A. Cuevas, R. Lopes V. Roque, J.Oliveira,
MICMC2005 IEEE International Workshop on Management Issues and Challenges in Mobile Computing
May 2005,
Nice, France

- "End-to-end QoS Architecture for 4G Scenarios"

Sargento, S., Prior, R., Sousa, F., Gonzalves, P., Gozdecki, J., Gomes, D., Guainella, E., Cuevas, A., Dziunikowski, W., Fontes, F.
IST SUMMIT 2005, JUNE 2005,
Dresden, Germany

- "Experimental Results with Forward Erasure Correction and Real Video Streaming in Hybrid Wireless Networks"

Paolo Barsocchi, Alberto Gotta, Francesco Potorti, Francisco J. Gonzalez-Castaño, Felipe Gil-Castiñeira, Jose I. Moreno, Antonio Cuevas
International Symposium on Wireless Communication Systems 2005 (ISWCS2005)
Siena, Italia,
September 2005,
ISBN 0-7803-9207-8
IEEE Catalog Number 05EX1092C

- "Integración de servicios multimedia en redes 4G"

R. Sanchez Martin, A. Cuevas Casado, J. I. Moreno Novella, P. A. Vico Solano
V Jornadas de Ingeniería Telemática. JITEL 2005
Vigo, Spain,
Septiembre 2005,
ISBN: 84-8408-346-2

- "Evaluación Experimental de las prestaciones de la Tecnología Bluetooth"
V. Tellez Garcia-Moreno, J. I Moreno Novella, A. Cuevas Casado, P. A. Vico Solano, D. Haage
V Jornadas de Ingeniería Telematica. JITEL 2005
Vigo, Spain,
Septiembre 2005,
ISBN: 84-8408-346-2

- "Cross System Engineering for Next Generation Networks"
P. Vidales, A. Cuevas
ICON2006
IEEE International Conference on Networks
September 2006
Singapore
ISSN 1556-6463
ISBN 0-7803-9746-0