MIMAX

Advanced ***MI***MO Systems for ***MAX***imum Reliability and Performance

SEVENTH FRAMEWORK PROGRAMME

European Commission
Information Society and Media

Introduction to the project MIMAX

The internet was introduced over 40 years ago. The first e-mail was sent out by Kleinrock, in 1969, from the University of California to the Stanford Research Centre, located several hundred kilometres away. Since the late sixties, the internet landscape has changed at a rapid pace. Today, daily business is deal with mostly through the internet, e-mail correspondence has become as important as ordinary post, latest information such as news and magazines are read online and the internet itself is progressively being replaced by the WEB 2.0 concept. Text-based websites are superseded by interactive, visual and audio content. Over the recent years, various revolutions have significantly changed the net infrastructure: where in the beginning users were connected by wires, today the demand for accessing e-mail and personal data at distance is ever increasing. But, why did the internet landscape change so drastically? Was this due to the fact that there was a lack of new technologies available in the past, or was it the potential market and users' volume to call for innovative solutions? Surely a combination of both: the users' pull on one side and the researchers' push have made the internet landscape what it is today.

Funded by the 7th Framework Programme of the European Union, the MIMAX project started in January 2008. It aims at investigating and developing a more powerful WLAN device, which is compatible with the existing WLAN networks. The project's concepts are based on Multiple-Input, Multiple-Output (MIMO) communication, which are similar to the approaches used in new WLAN standard 802.11n, in WiMAX or in LTE (advanced). Nevertheless, the main difference between MIMAX and the above mentioned standards is that the required signal processing is executed near the transmitting and receiving antennas in MIMAX. Therefore, synergies between multiple paths can be exploited and several components can be saved in comparison to those approaches. Consequently, more compact wireless radios can be used which also results in consuming less power. As a result of this paradigm shift, customised integrated circuits and systems need to be developed to compel with these new requirements in relation to the front-end processing concept and parts of the digital signal processing. MIMAX's approach is compatible with existing WLAN networks and able to achieve faster and more energy efficient data transmission. "Hic Rhodos, hic salta" (Lat. Aesop), MIMAX develops a system prototype to test and validate its concept in real scenarios. The use case will consist of a communication link between two laptops, which are both using MIMAX devices. The improvement in performance will certified according to the reliability of the communication, the achieved distance, and the throughput.

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MIMAX objectives

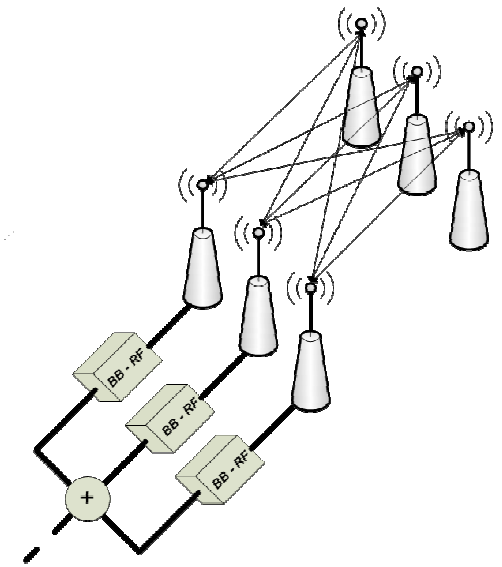
The structure, the content and the use of Internet are rapidly changing and they will continue to change in the near future. With computing power ever increasing, the main limitation in the information loop is represented by bandwidth and data rates, the speed at which information can be transmitted to the users. Moreover, with the merging of telephone and television technologies, the requirements for the available data rates will soon increase dramatically. Today, people no longer want to wait for information at a predetermined schedule but want it to be available and accessible to watch or download at any time and furthermore want it to be available either totally or partially according to their requirements of the moment.. This phenomenon can be referred to as “data personalization”. This new Internet paradigm calls for an “everywhere and any time” information offer merged with the data personalization. This progress is paving the way to a new era of information, where the critical point is not the data or information itself but how to approach it.

The current wireless technologies (802.11a, 802.11b, 802.11g, 802.11n), together with their mobile broadband candidates (GPRS, HSDPA, HSUPA) are the main trails to tackle these issues. Although these technologies are well known, the progress achieved so far is not significant and the solutions presented have not been able to fully meet the users’ needs. The is an important gap represented by the digital divide, i.e. people with effective access to digital and information technology and those with very limited or no access at all. MIMAX wants to make a breakthrough in this direction, developing a new technology able to satisfy the different users’ requests spanning between service ubiquity and data availability at reasonable costs.

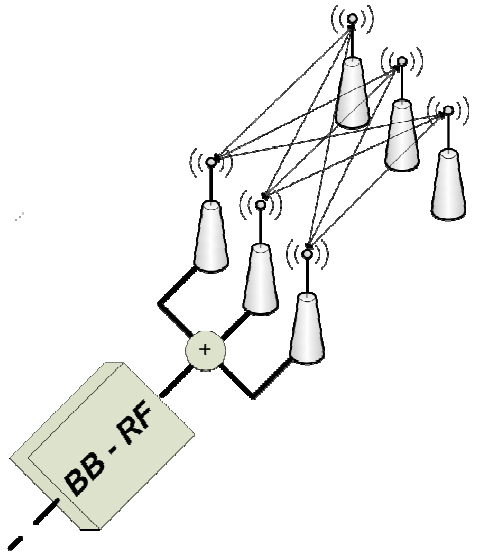
Technical Overview

MIMAX‘s technical concepts are based on MIMO technologies. In contrast to the approaches used in 802.11n WLAN, in WiMAX or in LTE, MIMAX uses signal processing close to the transmitting and receiving antennas exploiting synergies in the air interfaces. It therefore needs less components, can be manufactured more compactly and consumes less energy. MIMO processing is carried out in the analogue front-end by customized integrated circuits (ICs). These system blocks are able to weight the transmitted and received signals coherently to achieve maximum performance during data transmission. The challenge in designing these analogue weighting circuits is to achieve a reproducible signal processing as in digital hardware. Therefore, customized ICs are developed that exploit the concept of RF spatial combining with low power consumption.

Conventional MIMO concept (simplified)
Spatial signal processing in the baseband



MIMAX’s MIMO concept (simplified)
Spatial signal processing in analogue RF front-end



Technical overview

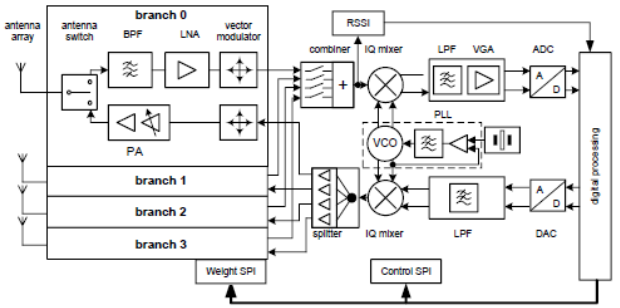
These analogue weighting ICs are controlled by means of MIMAX's signal processing algorithms. They are able to optimize the communication with respect to different goals, e.g., to extend the communication distance or to improve the reliability. Moreover, the algorithms consider analogue effects during the data transmission, i.e., analogue impairments are compensated in the digital domain to such an extent that the analogue signal processing becomes as reliable as the digital hardware. These choices enabled to achieve of a inter-operable system with the pre-exiting systems 802.11a WLAN at 5 GHz. Why is this needed besides the compatibility with applications and mobile services? MIMAX enhances the WLAN 802.11a with MIMO concepts. In its original version, this WLAN standard was not designed for MIMO and, hence, did not provide sufficient information to achieve an optimum MIMAX communication. Thus, novel features in the communication must be integrated to extend WLAN with MIMAX and to ensure that "old" devices are still operative with the new MIMAX tools.

Additionally, if a MIMAX user has been already identified why not achieve the full performance already at the beginning of the data transmission? Usually at the start-up, information is exchanged to optimise the link performance. If MIMAX uses parameters which have been obtained during a past data transmission, even at the start-up procedure, substantial performance gain will be achieved. Proving the concept is essential to investigate the performance parameters in real environments such as local offices or in-house areas. Therefore, MIMAX will develop a prototype system that consists of a multiple antenna array, the customized analogue ICs, the new digital signal processing algorithms and the access techniques. Assembled in two laptop -sized mock-ups, the test scenarios will verify the concept and benchmark its performance with respect to existing WLANs.

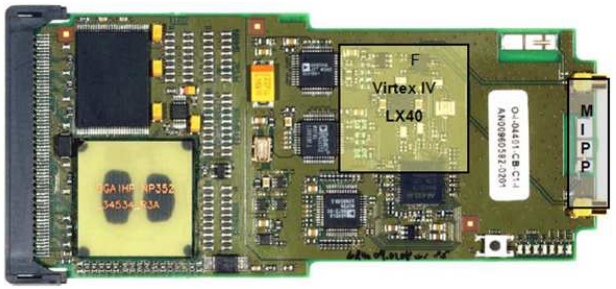
MIMAX expects significant improvements with respect to the reliability of the communication, the supported distance and the communication throughput. Fields of applications, for which this concept is very attractive, comprise private and business sectors, e.g., wireless Triple- or Quad-Play services, smart home automation or mobile grid computing including virtual augmented reality.

MIMAX's concepts

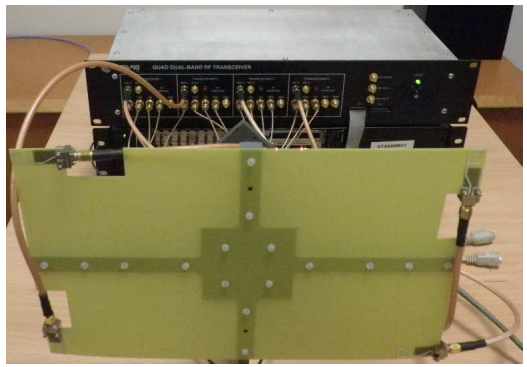
- Spatial combining in the RF domain
- Algorithms for beamformer selection and channel estimation
- MAC protocol extension for compatibility



MIMAX front end concept



Signal processing platform



MIMAX first Prototype

MIMAX in the real world

Triple-Play is considered nowadays as one of the key businesses areas of the most telecom companies.

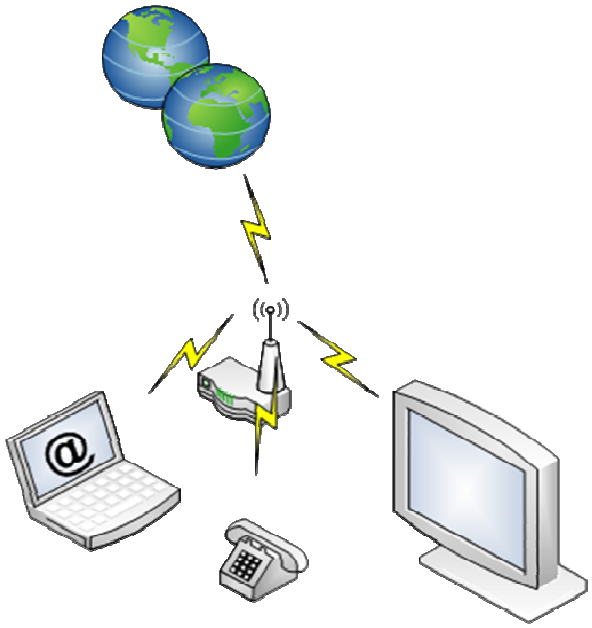
MIMAX can become an enabling technology to transfer these services to wireless Triple-Play and to ensure a competitive infrastructure. The main aspect which is addressed in MIMAX consists of the link reliability compared to existing standards in the same environment. By using MIMAX,

Triple-Play providers could offer their services through wireless links and succeed in penetrating hard-to-reach regions such as rural areas. Moreover, this also applies to mobile devices, e.g., one person can download and watch video from its mobile device using the MIMAX technology.

Overall, the MMAX concept can be applied to all mobile broadband technologies.

Examples of Triple-Play

- Interactive music video jukebox
- Digital photo frames
- Chat via keyboard and SMS/MMS
- Messaging
- E-Mail
- Information kiosk
- Radio and TV
- Horse racing betting,
- Video-on-demand applications
- Search and view internet videos
- Telephony user interface



Smart environments

Smart environments are complex systems, where information flow is used to improve the environment performance by means of cooperation among services and devices.
The use of wireless technologies inside buildings is ever increasing and a great number of services and devices used in these smart environments are equipped with wireless technologies, e.g., 802.11a/b/g/n, Bluetooth or ZigBee.
Smart environments are characterized by managing and controlling different functionalities such as:

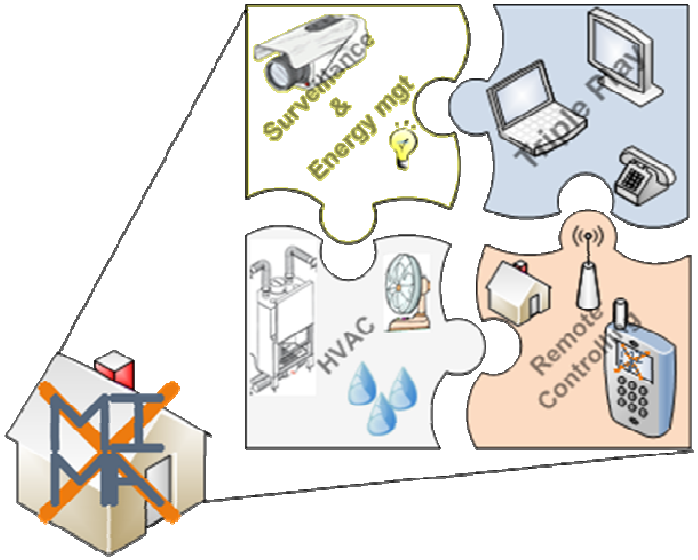
- Intrusion detection
- HVAC
- Internet connection
- Video streaming

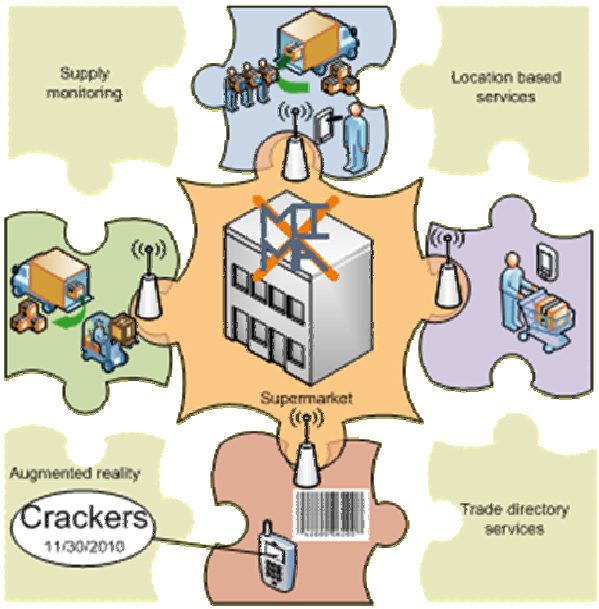
All these functionalities can be usually enabled by existing wireless protocols and technologies. However, MIMAX can assure all the services at better performances levels in the links and mobile devices. MIMAX can ensure link quality with lower power consumption of mobiles which is one of the key aspects in smart environments.

MIMAX applications

Using the current wireless communication protocols, only limited video streaming can be managed due to a relatively low available bandwidth and due to interferences by other nearby wireless networks. The current video packet size exceeds more than one 802.11 packet and the effect loosing one 802.11 packet depends on its contents. This loss will affect other correctly received packets and, therefore, the propagation effects of a packet loss can be significant. Single packet errors typically correspond to the loss of a small frame or the loss of a part of a big frame, but the loss of an entire burst means a significant degradation. In the future, it can be assumed that the number of coexisting wireless networks will further increase. This trend, in cooperation with their random deployment, will result in a highly crowded radio environment, interferences, packet collisions, low channel availability or low signal quality. Here, MIMAX can contribute to:

- Reduced interferences
- Increased channel bit rates
- Improved quality of the links
- Reduced costs in terms of power consumption and equipment





MIMAX in the ICT world

With the results reached during the first year, MIMAX was awarded the EEEfCOM Innovation Award 2008. MIMAX's consortium is highly involved in several events regarding Radio Access and Spectrum. All partners are particularly active in diversified dissemination activities to diffuse the MIMAX concepts to a wide range of stakeholders. The consortium organizes and participates to an important number of events such as:

The MIMAX project has been raising the interest from several organisations thanks to the dissemination activities provided by each partner. From December 2008 to September 2009, three different exploitation workshops (one in Rome and two in Cyprus) were carried out. News and articles about MIMAX can be found on the project website, including performance demonstration of the concept.

During the exploitation workshops, MIMAX's performances were demonstrated in live test beds and video is available on the MIMAX website that showcases the performance improvements and demonstrates the functionality of the concept:

http://www.ict-mimax.eu/

MIMAX Consortium

TECHNISCHE UNIVERSITÄT DRESDEN

Website: www.tu-dresden.de
Reference person: Ralf Eickhoff
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Role in the project: Circuit design and project management

Main Activity:
The Chair for Circuit design and Network Theory (CCN) at TUD is devoted to the design of high-speed integrated circuits using advanced circuit techniques and technologies. Applications mainly involve wireless communications up to 220 GHz and optical communications up to 80 Gbit/s. The CCN incorporates the experience of 2 professors, 1 post-doc and project manager, 12 PhD students and 4 technical staff members.

UC UNIVERSIDAD DE CANTABRIA

Website: www.unican.es
Reference person: Ignacio Santamaría
E-mail: nacho@gtas.dicom.unican.es
Role in the project:: Adaptive baseband processing

Main Activity:
The Advanced Signal Processing Group (GTAS) was founded in 1991 at UC and its major research activities comprise the development of digital signal processing algorithms for communications, as well as machine-learning techniques and nonlinear modelling. Currently, the research activity is focused on signal processing techniques for MIMO communication and machine-learning techniques and their application to communications.

ihp

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Reference person: Rolf Kraemer
E-mail: kraemer@ihp-microelectronics.com
Role in the project: System development and circuit design

Core Business:
The IHP has a team of 204 R&D professionals with core competence in microelectronics: process technology, circuit design, and systems. The institute is focused on developing innovative solutions for wireless communication. Its expertise ranges from system and circuit design to the implementation and optimisation of protocol stacks and the development of system-enabling CMOS compatible technology modules. IHP has long years experience in wireless systems research especially RF-component design, baseband processor design, MAC-processor design and wireless sensor networks.

TTI

Website: www.ttinorte.es
Reference person: Laura Gonzàlez
E-mail: lgonzalez@ttinorte.es
Role in the project: Antenna design and integration

Core Business:
TTI is a small/medium sized enterprise that was founded in 1996. Today, TTI works in the technological forefronts of space, military, telecommunications, science, and information technology sectors. Its main expertise areas are active antennas, microwave and RF technologies, and satellite systems engineering.

T-connect

Website: www.t-connect.it
Reference person: Paolo Sperandio
E-mail: paolo.sperandio@t-connect.it
Role in the project: Mobile application services

Core Business:
T-Connect is engaged in research and development of wireless applications on 3G platforms (UMTS, WLAN) for mobile communications services.

PRIMETEL Total Communication

Website: www.prime-tel.com
Reference person: Theodosis Theodosiou
E-mail: ththeodosis@prime-tel.com>
Role in the project: Service provider for wired and wireless communication networks

Core Business:
PrimeTel is an electronic communication and information technology company based in Cyprus that owns and operates a truly regional network, spanning Cyprus, Greece, UK and Russia, providing voice, data and IP services to business and residential customers as well as wholesale services to carriers, mobile operators, content, application and internet provider.