INSTITUT FÜR NACHRICHTENTECHNIK UND HOCHFREQUENZTECHNIK

DOKUMENTATION

STAND: 1. OKTOBER 2003

Überarbeitete Version März 2004

INSTITUT FÜR
NACHRICHTENTECHNIK UND
HOCHFREQUENZTECHNIK

TU WIEN

TECHNISCHE
UNIVERSITÄT
WIEN

VIENNA
UNIVERSITY OF
TECHNOLOGY

INHALT / CONTENTS

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Stand 30.09.2003

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COST 277 „Nonlinear Speech Processing“
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EU IST Programme
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Université de Marne La Vallée

AKTUELLE FORSCHUNGSGEBIETE: ÜBERSICHT / CURRENT RESEARCH AREAS: SYNOPSIS

Im Bereich der *digitalen Signalverarbeitung* bearbeiten wir derzeit die folgenden Schwerpunkte: *Zeit-Frequenz-Signalverarbeitung*, *Digitale Filter und adaptive Systeme* sowie die *Automatische Generierung optimierter Programme für Signalprozessoren*.

Die Arbeitsgruppe *Zeit-Frequenz-Signalverarbeitung* entwickelt Methoden zur Analyse, Verarbeitung, Modellierung und Simulation von hochgradig instationären Signalen und schnell zeitvarianten Systemen bzw. Kanälen. Unsere derzeitigen Arbeiten konzentrieren sich auf den Einsatz neuartiger Zeit-Frequenz-Methoden in der Mobilkommunikation. Wir entwickeln Algorithmen zur Kanalschätzung und -prädiktion, Zeit-Frequenz-Synchronisierung und Impulsoptimierung für OFDM-Systeme. Ein neuartiges Raum-Zeit-Modulationsverfahren und ein effizienter iterativer Decodieralgorithmus ermöglichen schnelle Datenübertragung über Mehrfachantennen-Funkverbindungen auch ohne Kenntnis der Kanaleigenschaften. Als Teilnehmer eines EU/IST-Projekts setzen wir fortschrittliche Signalverarbeitungsalgorithmen zur Analyse von Gleichkanal-Interferenz in UMTS-Netzen und zellularen DVB-T-Netzen ein.

Wir entwickeln weiters Zeit-Frequenz-Methoden zur Modellierung und Simulation von zeitvarianten Systemen und Mobilfunkkanälen. Zeit-Frequenz-Filter erlauben eine einfache Spezifikation zeitvarianter Filtercharakteristiken. Zeit-Frequenz-Leistungsdichtespektren ergeben eine hochauflösende Spektralanalyse instationärer Zufallssignale. Neuartige Zeit-Frequenz-Methoden zum Entwurf und zur Implementierung instationärer Signalschätzer und -detektoren zeichnen sich durch hohe statistische Robustheit und numerische Effizienz aus.

Die Leistungsfähigkeit moderner Signalprozessoren kann nur durch effiziente Programme wirklich ausgenutzt werden. Dazu entwickeln wir *Algorithmen für die automatische Umsetzung von Datenflußgraphen* in optimierte Programme für Signalprozessoren. Auf diesem Gebiet bestehen enge Kooperationen mit Industriefirmen.

Ein weiteres Forschungsgebiet umfasst die Entstörung verrauschter Audiosignale mit Hilfe *adaptiver Filter und Filterbänken*. Neben dem Entwurf von Multiratenfilterbänken werden auch adaptive Algorithmen zur Modifikation der einzelnen Teilbandsignale entwickelt. In Kooperation mit einem Industriepartner werden derzeit Anwendungen im Bereich adaptiver, ein- und zweidimensionaler Mikrofon- und Lautsprecherarrays untersucht.

In the area of *digital signal processing* we focus on the following topics*: Time-frequency signal processing*, *digital filters and adaptive systems*, and *automatic program generation for signal processors*.

The *time-frequency signal processing* group is developing techniques for the analysis, processing, modeling, and simulation of highly nonstationary signals and fast time-varying systems/channels. Our current work focuses on the application of time-frequency techniques to mobile radio communications. We develop algorithms for channel estimation/prediction, time-frequency synchronization, and pulse optimization within OFDM systems. In the framework of an EU/IST project, we use advanced signal processing to analyze co-channel interference within UMTS networks and cellular DVB-T networks. Recently, we devised a novel space-time modulation technique and an efficient iterative decoding algorithm that allow to boost bit rates over multi-antenna wireless links with unknown channel characteristics.

We are also developing and studying time-frequency techniques for the modeling and simulation of time-varying systems and mobile radio channels. Time-frequency filters allow an easy specification of time-varying filter characteristics. Novel time-frequency power spectra perform a high-resolution spectral analysis of nonstationary random signals. Our time-frequency designs and implementations of nonstationary signal detectors and estimators are statistically robust and numerically efficient.

The exploitation of the full performance of modern signal processors requires efficient programs. To meet this challenge, we develop *algorithms for the automatic conversion of data flow graphs* into highly optimized programs for signal processors. In this area there exist close cooperations with industrial companies.

Another research area comprises the enhancement of noise-corrupted audio signals using *adaptive filters and filterbanks*. Besides the design of multirate filterbanks, a number of adaptive algorithms is developed for the modification of the subband signals. In cooperation with an industrial partner, we currently investigate design and application of two-dimensional adaptive microphone arrays.

Die Abteilung *Codierung und Datenübertragungsverfahren* beschäftigt sich mit der Optimierung von Übertragungssystemen. Von aktuellem Interesse sind zeitvariante Mobilfunkkanäle (stochastisch auftretender Schwund). Das Gedächtnis des Kanals wird dabei als innerer Code interpretiert und Modulation und äußere Codierung darauf abgestimmt.

In letzter Zeit wurden verschiedene Codierverfahren (Turbo-Codes, Low density parity check codes, Mehrdimensionale Produkt-Codes) bekannt, mit denen

In the area of *coding and data transmission* we try to optimize data transmission over difficult channels by combining modulation, equalization and channel coding.

Today we focus on time variant mobile radio channels with deep fades. Methods like Turbo-equalization are investigated to cope with the resulting intersymbol interference. In some cases the channel memory can be considered as inner code. Then the outer code can be matched to the inner code and recursive detection

man praktisch die Shannon´sche Kanal-Kapazität erreicht. Ein brandaktuelles neues Forschungsgebiet ist die Raum-Zeit-Codierung, bei der Sender und Empfänger in Form von Antennengruppen realisiert sind. Die Theorie zu diesem Verfahren verspricht hohe Diversität und hohen Codegewinn sowie eine Steigerung der Kanalkapazität um eine Größenordnung. Dafür effiziente Raum-Zeit-Codes zu finden, ist eine faszinierende Aufgabe.

Wir untersuchen sowohl Raum-Zeit Block Codes als auch Raum-Zeit Trellis Codes und ihre Gewinne in Bezug auf eine größere Diversität bzw. ihre Gewinne in Bezug auf eine Reduktion der benötigten Sendeleistung (Code Gewinne). Von großem Interesse sind die Gewinneinbußen bei zunehmender Korrelation der Teilübertragungsfunktion zwischen den einzelnen Antennen–Elementen. Mit zunehmender Korrelation gewinnen die adaptiven Antennen (smart antennas) mit einstellbarer Richtcharakteristik an Bedeutung. Diese Thematik wird in der Mobilfunkgruppe an unserem Institut seit längerer Zeit sehr erfolgreich bearbeitet.

In der *Mobilkommunikation* arbeiten wir mit der Mobilkom Austria AG zusammen auf den Gebieten Optimierung von Mobilfunknetzen, UMTS (Universal Mobile Telecommunications System), Scheduling für paketvermittelte Dienste, künftige neue Systeme sowie Funkzugang zum Internet. In Zusammenarbeit mit Partnern am ftw., in Helsinki, Paris und Ilmenau verfeinern wir Modelle des Funkkanals, die seine letzte noch ungenützte Komponente, nämlich die räumliche, in bisher nicht erreichtem Detailreichtum beschreiben. Diese Charakterisierung wird erforderlich, wenn man die ungeheure Übertragungskapazität der neuen MIMO Systeme nutzen will. MIMO steht für multiple-input multiple-output und beschreibt Funkstrecken/system, die bei Sender und Empfänger Antennengruppen einsetzen.

In einer neuen Forschungskooperation mit dem japanischen Netzbetreiber NTTDoCoMo untersuchen wir die Eignung von MIMO Kanälen für ultra-schnelle Funkübertragung für die 4. Generation von Mobilfunksystemen (“Beyond 3G”), die ab 2010 eingesetzt werden soll.

Für intelligente (adaptive) Antennen entwickeln wir Algorithmen für die Auf- und Abwärtsstrecke, die auf Signalprozessoren in Echtzeit implementiert sind. Mit „blinden“ Algorithmen nutzen wir strukturelle Eigenschaften der Mobilfunksignale, um gewünschte Teilnehmer von unerwünschten zu trennen, selbst wenn sie räumlich nicht trennbar sind. Die Ergebnisse der COST Aktion 259 „Wireless Flexible Personalized Communications“ wurden als Buch veröffentlicht, in dem unsere Mitarbeit an führender Stelle (Arbeitsgruppenleiter Antennen und Wellenausbreitung, Autoren mehrerer Kapitel) dokumentiert ist. In COST 273 führen wir dieselbe Arbeitsgruppe weiter, die Unterarbeitsgruppe über MIMO-Kanäle wird von einem unserer Absolventen betreut.

Die Spezialausbildung in der Mobilkommunikation, zu der verschiedene Bereiche des Instituts beitragen, zieht Studenten aus ganz Europa an. Mit der ETH Zürich und der TU München bieten wir ein gemeinsames Mobilfunkseminar an.

methods can be applied.
Examples of most effective codes like Turbo-codes, low density parity check codes, and product codes, which have been become popular in the very last time are under investigation. A newly attacked field of investigation are space-time codes applied to antenna arrays. With this approach diversity and channel capacity can be increased by an order of magnitude.

Several quasi-orthagonal Space-Time Codes for various multiple antenna element systems are under investigation.

Several low complexity decoding alorithms approaching optimal performance have been studied.

In the field of *mobile communications*, we cooperate with Mobilkom Austria AG on mobile network optimization, UMTS (Universal Mobile Telecommunications System), scheduling for packet-switched services, future systems, and radio access to the internet. In cooperation with groups at ftw and in Helsinki, Paris and Ilmenau we refine models of the mobile radio channel that exploit the last frontier of this channel, the spatial component. We can establish directions of arrival and of departure (DOAs, DODs) with unprecedented precision in several domains at the same time. Such characterization of the mobile radio channel becomes crucial to put to use the enormous transmission capacity, offered theoretically by MIMO systems. MIMO stands for multiple-input multiple-output and describes radio links with antenna arrays at the receiver and at the transmitter.

In a research collaboration with NTTDoCoMo of Japan we will investigate MIMO channels´ usefulness for high-speed wireless access of the 4th generation of mobile radio systems (“Beyond 3G”), to be deployed from about 2010 onwards.

We develop smart antenna algorithms for up- and downlink, which are implemented on a DSP in real time. With so-called „blind“ algorithms we utilize structural signal properties to separate and detect desired/ interfering user signal, which are not separated in the spatial domain. Our leading involvement in COST 259 „Wireless Flexible Personalized Communications“ is documented in the book about this action (chapter authors, chairman of the working group on antennas and propagation.)

We continue this leadership in COST 273 „Towards Mobile Broadband Multimedia Networks“. The newly founded sub-working group on MIMO is led by an alumni of our group.
The dedicated course plan in mobile communications draws students from all over Europe. Together with ETH Zurich and TU Munich we offer an International Seminar on Mobile Communications.

Der Schwerpunkt der Forschung auf dem Gebiet der *Digitalen Signalverarbeitung in der Mobilkommunikation* liegt in den Methoden des Rapid Prototyping. Dabei werden Ideen und Algorithmen der digitalen Signalverarbeitung sehr schnell in Echtzeitexperimente umgesetzt. Aussagen über die technische Realisierbarkeit sind schon sehr früh möglich. Konkret befassen wir uns mit Verfahren zur Kanalschätzung für sehr schnell veränderliche Kanäle, wo lange Beobachtungszeiten für die Schätzung von Kanalparametern nicht möglich sind. Wir entwickeln eine adaptive, nichtlineare Vorverzerrung für UMTS-Endverstärker, um nichtlineare Verzerrungen des Sendesignals und störendes Übersprechen in Nachbarbänder zu verringern. Wir entwickeln weiterhin Empfänger für Mehrfachantennensysteme (MIMO-Systems) und bauen dazu echtzeitfähige Prototypen. Weiters befassen wir uns mit Entzerrerstrukturen für UMTS- und Mehrfachantennensysteme. In Zukunft werden auch Funksysteme der 4.Generation untersucht werden. Die größten Verbesserungen gegenüber Systemen der 3.Generation (UMTS) werden momentan in der Verbindung von Kanal- und Quellkodierung gesehen; auch neuartige Kodierungsmethoden und Methoden zur Fehlerverdeckung zielen auf weitere Verbesserungen ab. Ein Systemdesign unter Einschluss solcher Methoden ist eine sehr lohnende Herausforderung für die zukünftige Forschungen.

Signal Processing in Mobile Communications focuses on methods for rapid prototyping. Here, system concepts and algorithms are mapped rapidly into real-time experiments, hence, allowing to conclude technical feasibility at an early stage of the development process. Hereby, we are investigating rapid channel movements in which channel estimation based on long periods for observation are not available. We develop adaptive, nonlinear predistortion techniques for UMTS power amplifiers, in order to reduce nonlinear distortion in neighboring bands. Furthermore, we develop receiver for multiple transmit and receive antenna systems (MIMO) and investigate possible structures for equalizers in UMTS and MIMO receiver systems for which we also build real-time prototypes. In future, also wireless systems of the fourth generation will be a focus. The most important improvements when compared with 3rd generation wireless systems (UMTS) are expected in the combination of channel and source coding. Also new methods for error concealment are of interest. A complete system design based on such new techniques is a very interesting challenge for the future.

Das im Juli 2002 gegründete Christian Doppler Pilotlabor für Designmethodik für Signalverarbeitungsalgorithmen ist mittlerweile mit drei Mitarbeitern voll besetzt. Die Arbeitsgebiete umfassen sowohl Entwurf auf der Algorithmikebene als auch in der Architekturebene. Durch selbst erzeugte so genannte translatorische Werkzeuge sind wir in der Lage zunächst nichtkompatible Designwerkzeuge in konsistenter Weise zu verknüpfen. Dies erlaubt uns auch komplexe Entwürfe, wie sie für ein UMTS Handi-Chip von Infineon erforderlich sind, innerhalb von Sekunden automatisch von einer Beschreibungsebene in die andere zu transferieren, eine Aufgabe mit der früher viele Mitarbeiter mehrere Monate beschäftigt waren

The Christian Doppler Pilot Laboratory for Design Methodology of signal processing algorithms, founded in July 2002, is with three researchers fully operational now. The research covers design on the algorithmic level as well as in the architectural level. By self written so called translatorial tools we are able to integrate consistently prior non-compatible tools. This allows us to transfer automatically even designs of highest complexity as given for a UMTS cellular phone chip from Infineon, in a few seconds from one description level to another, a task which required several persons for a couple of months in prior times.

Auf dem Gebiet der *Hochfrequenztechnik* beschäftigen wir uns mit integrierten Schaltungen in Si und SiGe Technologien. Das Ziel dieser in Zusammenarbeit mit Infineon Technologies AG durchgeführten Untersuchungen ist es, die physikalischen Grenzen der Herstellungsverfahren auszuloten.

Einige Arbeiten befassen sich mit Sonderformen von Funkantennen und der Erfassung der Leistungsfähigkeit von Bluetooth-Verbindungen in industrieller Umgebung.

Gemeinsam mit dem Institut für Astronomie der Universität Wien sind wir dabei, eine Erdefunkstelle in städtischer Umgebung für die Kommunikation mit LEO-Satelliten aufzubauen.

In the domain of *radio frequency technology* we deal with the design of integrated circuits in Si and SiGe technologies. The goal is to find out the physical limits of chip performance for existing fabrication methods. Our industrial partner here is Infineon Technologies AG.

Further, we are involved in the custom design of antennas and in testing of Bluetooth-links in industrial scenarios.

Together with the University Vienna we are just setting up a ground station in the urban area for communication with low earth orbiting satellites.

Auf dem Gebiet der *Optischen Nachrichtentechnik* untersuchten wir für die Europäische Weltraumbehörde ESA gemeinsam mit der Abteilung Quantenexperimente von Prof. Zeilinger (Universität Wien) Konzepte zur optischen Datenübertragung, die auf der Quantenmechanik beruhen. Eine typische Anwendung

In the area of *optical communications* we teamed up with Prof. Zeilingers group at Vienna University to investigate, for the European Space Agency ESA, concepts for optical space communications based on the principles of quantum mechanics. A typical application would be quantum key distribution for cryptographic

wäre der Schlüsselaustausch für krytographische Zwecke zwischen einer Bodenstation und einem Satelliten. Im speziellen wurde die Internationale Raumstation ISS als Plattform für das Weltraumsegment ins Auge gefasst. Unsere Aufgabe bestand darin, die Möglichkeit der Adaptierung bestehender Technologien für die Quantenkommunikation zu erkunden und die Anforderungen an ein satellitengestütztes System zu umreißen. Das Ergebnis ist ein Vorschlag für ein vierstufiges Experiment das es ermöglicht, unter Zuhilfenahme einer Quelle von verschränkten Photonen an Bord der ISS einen Schlüssel zwischen zwei Bodenstationen auszutauschen.

Auf dem Konzept eines Interferometers beruht das Vielfach-Raumteleskop mit dem im Rahmen der ESA-Mission DARWIN extrasolare Planeten vermessen werden sollen. Gemeinsam mit EADS Astrium/D und TNO/NL wurde ein Versuchsaufbau zum Testen der Unterdrückung des bei DARWIN extrem störenden Sternenlichtes realisiert. Mit dem im nahen Infrarot arbeitenden und aktiv geregelten Interferometer konnte die erforderliche, extrem schmale Antennenkeule demonstriert werden. Ein erster Schritt zur praktischen Realisierung von DARWIN stellt das ESA-Projekt "Single-Mode Fibers for DARWIN" dar. Darin wird eine Single-Mode-Faser für den Wellenlängenbereich von 4 μm bis 20 μm entwickelt, die als räumliches Modenfilter dienen soll. Im Rahmen dieses Projekts untersuchen wir Silber-Halid-Fasern mit Hilfe eines im mittleren Infrarot arbeitenden Mach-Zehnder Interferometers auf Monomodigkeit und dadurch auf ihre Eignung zur Modenfilterung.

Gemeinsam mit Contraves Space/CH untersuchen wir Methoden zur effizienten Einkopplung von optischen Freiraum-Wellen in Glasfasern. Die adaptiven Konzepte, die auf sich ändernde Umwelteinflüsse reagieren können und dadurch einen besonders hohen, zeitlich stabilen Einkoppelgrad ermöglichen, werden sowohl für den Einsatz in der optischen Freiraumkommunikation als auch für die astronomischen Interferometrie benötigt.

purposes along a link between a ground station and a low-Earth-orbiting satellite. More specifically, we envisaged the international space station (ISS) to serve as carrier for the space borne terminal. We had to explore the possibility of adapting existing technologies for quantum communications and define the requirements on a satellite-based system. The result is a proposal for a four-step experiment allowing an absolutely secure key exchange between two ground stations, using a source of entangled photons on board the ISS.

The multiple space telescope to be developed for probing extra-solar planets within ESA's DARWIN mission is based on the principle of interferometry. Together with EADS Astrium/D and TNO/NL we designed a setup to test the suppression of the highly disturbing star light. It operated in the near infrared and demonstrated the required extremely narrow antenna pattern. A first step towards a practical realization of DARWIN is ESA's study "Single-Mode Fibers for DARWIN". Here a single-mode fiber is to be developed to act as a spatial filter in the 4 μm to 20 μm wavelength range. Within this project we test silver-halide fibers with respect to being single-moded (and thus being useful as spatial mode filter), employing a Mach-Zehnder interferometer.

Together with Contraves Space/CH we investigate methods to efficiently couple optical free-space radiation into glass fibers. The adaptive concepts in mind can respond to changing environment and thus allow a stable, high coupling efficiency. They are required for applications in both astronomic interferometry and in free-space laser communications.

ERNENNUNGEN VON UND PREISE AN MITARBEITER / NOMINATION AND AWARDS

30.9.2002 - 1.10.2003

Gritsch Gerhard, GIT Förderpreis 2002

LEHRVERANSTALTUNGEN / COURSE PROGRAM

im Studienjahr 2003/2004

1. Pflichtlehrveranstaltungen / Mandatory Courses

			WS	SS
Weinrichter:	Einführung in die Nachrichtentechnik	VO	—	3,0
Dortschy:	Einführung in die Nachrichtentechnik	UE	—	1,5
Weinrichter:	Einführung in die Telekommunikation	VO	2,0	—
Weinrichter:	Grundlagen nachrichtentechn. Signale	VO	—	2,0
Zeitlhofer:	Grundlagen nachrichtentechn. Signale	UE	—	1,0
Magerl:	Hochfrequenztechnik 1	VO	—	2,0
Trojer:	Hochfrequenztechnik 1	UE	—	1,0
Ehrlich-Schupita:	Hochfrequenztechnik 2	VO	2,0	—
Ehrlich-Schupita:	Hochfrequenztechnik 2	UE	1,0	—
Mecklenbräuker, Bonek, Leeb, Weinrichter, Rupp:	Nachrichtentechnik Labor A	LU	—	5,0
Bonek, Mecklenbräuker, Leeb, Weinrichter:	Nachrichtentechnik Labor B	LU	9,0	—
Bonek:	Nachrichtentechnik Labor für TPH	LU	—	4,0
Leeb:	Optische Nachrichtentechnik	VO	2,0	—
Pfennigbauer, Safer:	Optische Nachrichtentechnik	UE	1,0	—
Mecklenbräuker:	Signal- und Systemtheorie 1	VO	1,5	—
Rank:	Signal- und Systemtheorie 1	UE	1,0	—
Mecklenbräuker:	Signal- und Systemtheorie 2	VO	—	1,5
Doblinger:	Signal- und Systemtheorie 2	UE	—	1,0
Mecklenbräuker, Doblinger:	Signale und Systeme 2	VU	—	3,0
Hlawatsch:	Übertragungsverfahren 1	VO	2,0	—
Seethaler:	Übertragungsverfahren 1	UE	1,0	—
Hlawatsch:	Übertragungsverfahren 2	VO	—	2,0
Matz:	Übertragungsverfahren 2	UE	—	1,0
Bonek:	Wellenausbreitung 1	VO	2,0	—
Jachan:	Wellenausbreitung 1	UE	1,0	—
Bonek:	Wellenausbreitung 2	VO	—	2,0
Özcelik:	Wellenausbreitung 2	UE	—	1,0

2. Wahllehrveranstaltungen / Optional Courses

			WS	SS
Rupp, Aschbacher	Adaptive Filter	VU	—	3,0
Kreuzgruber:	Angewandte HF-Technik	KO	—	1,0
Scholtz:	Antennentechnik	LU	—	2,0
Mecklenbräuker, Doblinger, Zeitlhofer:	Digitale Signalverarbeitung A	SE	3,0	—
Mecklenbräuker, Doblinger, Zeitlhofer:	Digitale Signalverarbeitung B	SE	—	3,0
Wess:	Dimensionierung und Simulation analoger Filter	SE	1,5	—
Professoren und Assistenten:	EDV-orientierte Projektarbeit für ET	AG	4,0	4,0
Weinrichter:	Einführung in die Codierung	VO	2,0	—
Kommenda:	Ein- und Ausgabe von Sprache	VO	2,0	—
Garn:	Elektromagnetische Verträglichkeit elektronischer Geräte	VO	—	1,5
Lamedschwandner, Garn:	Elektromagnetische Verträglichkeit elektronischer Geräte	UE	—	1,5
Weinrichter:	Filter	VO	1,5	—
Scholtz:	Funkweitverkehrstechnik	VO	1,5	—
Braunbeck:	Geschichte der Nachrichtentechnik	VO	1,5	—
Leeb:	Glasfaser-Nachrichtensysteme	VO	—	1,5
Scholtz:	Hochfrequenz-Schaltungstechnik	KO	—	1,5
Hlawatsch:	Information Theory for Communications Engineers	VO	2,0	—
Magerl:	Integrierte Mikrowellenschaltungen	VO	—	1,5
Bonek, Leuthold, Nossek:	Internationales Seminar Mobile Kommunikation	SE	—	3,0
Leeb:	Kohärente optische Empfänger	VO	—	1,5
Ehrlich-Schupita:	Messgeräte der Hochfrequenztechnik A	KO	—	1,5
Magerl:	Mikrowellenmesstechnik	VO	1,5	—
Bonek, Weinrichter, Rupp:	Mobilfunk	KO	3,0	—
Bonek, Weinrichter, Rupp:	Mobile Radio Communications	KO	3,0	—
Rupp	Mobilkommunikation, Vertiefung	VU	4,0	—
Fröhling, Renner:	Numerische Methoden in der HF- und Mikrowellentechnik	VO	1,5	—
Proksch:	Phasenregelschleifen in der Nachrichtentechnik	VO	—	1,5
Doblinger:	Programmieren von Signalverarbeitungsalgorithmen in C	SE	—	1,5
Ullrich:	Radartechnik	VO	—	1,5
Hlawatsch, Doblinger:	Research Projects in Advanced Signal Processing	SE	3,0	3,0
Weinrichter:	Schnelle Datenübertragung über Kabel (xDSL)	VO	3,0	—
Doblinger:	Signalprozessoren	VO	1,5	—
Mecklenbräuker, Doblinger, Matz:	Signalverarbeitung mit MATLAB	LU	3,0	—

			WS	SS
Hlawatsch:	Statistical Signal Processing	VO	—	2,0
Mecklenbräuker, van As, Magerl:	Telekommunikationsforum	KO	2,0	2,0
C. Mecklenbräuker	Mobilfunknetze der dritten Generation	VO	2,0	—
Müller	Multi-User Communications	VO	—	2,0
Matz	Signal Detection	VO	2,0	—
Mayr	Telekommunikation und Telekomm. Politik in Österreich	VO	1,5	—
Rupp	Verarbeitung Stochastischer Signale	VU	3.0	—

3. Gastvorträge / Guest Talks

Dr. Gerhard Kramer,	Turbo Codes und Iterative Decoding Bell Labs, Mathematics of Communications Research Department
Rene-Jean Essiambre,	Bell Laboratories, Lucent Technologies, Distributed Raman Amplification and High-Speed Communication Systems, 26.9.2003

4. Gastvorlesungen von Institutsmitgliedern / Guest Lectures by Members of the Institute

Tutorial „Smart Antennas and MIMO Systems“ by A. Molisch, J. Laurila, K. Hugl, and E. Bonek, Tenth IEEE Personal, Indoor, and Mobile Radio Conference PIMRC 2002, Lissabon, 15. 9. 2002

Tutorial „MIMO Channel Modeling Revisited“ by E. Bonek, W. Weichselberger, A. Molisch, and H. Hofstetter, COST 273 Prag, 24. 9. 2003

5. Gastvorträge von Institutsmitgliedern / Guest Talks by Members of the Institute

Artés, Harold,	Space-time matrix modulation for communication over unknown MIMO channels. University of California, Davis (CA), 1.11.2002
Artés, Harold,	Space-time matrix modulation for communication over unknown MIMO channels. Stanford University, 7.11.2002
Bonek, Ernst,	Telefonieren ist zu billig. Rotary-Club Wien-West, 10.7.2003
Bonek, Ernst,	Signal Processing and Wave Propagation - an Essential Symbiosis. ICEAA ´03, Turin, 9.9.2003
Bonek, Ernst,	Real-time DoA-based smart antenna processor for GSM 1800. Beijing University of Post & Telecommunications, Beijing, 20.11.2002.
Bonek, Ernst,	An experimenter‘s look at MIMO. The Int. Forum Future Mobile Telecommunications and China-EU Post Conference on Beyond 3G., China, Beijing, 22.11.2002.
Bonek, Ernst,	Link-specific MIMO systems deployment for ad-hoc networks. Wireless World Research Forum #7, Eindhoven, 3.12.2002.
Leeb, Walter,	Freiraum Laser-Kommunikation (Optical Free-Space Communications). Institut für Experimentalphysik, Universität Wien, 30.6.2003
Matz, Gerald,	Adaptive prediction of time-varying channels for wireless multicarrier systems. Laboratoire des Signaux et Systemes, Ecole Supérieure d’Electricité Gif sur Yvette (France), Nov. 2002

Matz, Gerald,	Adaptive channel prediction for equalization in wireless OFDM systems. Electrical Engineering Department, Univ. of California at Davis, Davis (CA), Nov. 2002
Mecklenbräuker, Wolfgang,	Dauer und Bandbreite. Kolloquium des Lehrstuhls für Multimediakommunikation und Signalverarbeitung, Universität Erlangen-Nürnberg, 28.2.2003
Rupp, Markus,	CD-Pilot-Laboratory: Design Methodology of Signal Processing Algorithms. Vortrag im Forschungszentrum Telekommunikation Wien (FTW) im Rahmen des laufenden Telekommunikationsforums, 9.1.2003.
Rupp, Markus,	Rapid Prototyping: The Five-Ones Approach. Vortrag im Rahmen des laufenden Forschungskolloquium des Communication Technology Labs der ETH Zürich, 15.1.2003.
Wallner, Oswald,	DARWIN - Astronomische Interferometrie zur Untersuchung von extrasolaren Planeten. Institut für Astronomie, Universität Wien, 20.1.2003
Weichselberger,Werner,	MIMO Communication Links: Introduction and Recent Advances. Radio & Wireless Conference (RAWCON) 2003, Boston, Massachusetts, USA, 11.8.2003.

6. Forum Telekommunikation / Telecommunications Forum

Wöchentliche Vortragsreihe gemeinsam mit ftw (http://www.ftw.at) mit Themen der drei Arbeitsbereiche Telekommunikationsnetze und -dienste, Signalverarbeitung für die Datenübertragung und Mobilfunk:

14. Oktober 2002: Frédéric Lehmann, Institut National Polytechnique de Grenoble, Frankreich, On the Link Between the Dynamics of Iterative Decoding and the Weight Enumerator of the Underlying Codes.

25. Oktober 2002: Nikos Sidiropoulos, Abteilung für Elektronik und Informatik, Techische Universität Kreta, Griechenland, Parallel Factor Analysis.

8. November 2002: Robert W. Bower, Alexander von Humboldt-Stiftung Awardee 2002 TU Berlin, Deutschland, Three Dimensional Nanoelectronic Technology.

15. November 2002: Akbar Sayeed, University of Wisconsin - Madison, USA, A Virtual Representation for Time- and Frequency-Selective MIMO Channels.

20. November 2002: Antonia Tulino, Department of Electrical Engineering, Università del Sannio, Italien, The theory of random matrices and its applications to wireless communication problems.

22. November 2002: Cees J.M. Lanting, HERMES Partnership, Leuven, Belgien. The Hermes Partnership, a European centre of Excellence in telecom research, and its initiatives for the EU's 6th Framework Programme.

29. November 2002: Magne Pettersen, Telenor Research and Development, Fornebu, Norwegen, Personalised access in a heterogeneous wireless world.

6. Dezember 2002: Gerhard Franz, PhD, A. G. Franz Associates, LLC, Plainsboro, New Jersey, USA, Mobile e-Commerce - will it take off? and Is there a Future for Satellite Communication?

20. Dezember 2002: Helmut Boelcskei, ETH Zürich, Schweiz, MIMO: What shall we do with all these degrees of freedom?

9. Jänner 2003: Markus Rupp, Pavle Belanovic, Daniel Micusik und Martin Holzer, TU Wien, Design Methodology of Signal Processing Algorithms in Wireless Systems.

17. Jänner 2003: Vladimir B. Balakirsky, St. Petersburg, Russland, Suboptimum Decoding Algorithm for Minimizing the Bit Error Probabilities for Binary Linear Block Codes and its Performance for Symmetric Memoryless Channels.

31. Jänner 2003: Anja Feldmann, TU München, Deutschland, Realistic BGP Traffic for Test Labs.

7. März 2003: Stephan ten Brink, Bell Laboratories, Lucent Technologies, USA, Iterative Detection and Decoding with Repeat-Accumulate Codes.

14. März 2003: Amer Catovic, New Jersey Center for Wireless Telecommunications, New Jersey Institute of Technology, USA, Looking beyond 3G: technologies and architectures for next generation wireless networks.

21. März 2003: Marius Pesavento, Ruhr-Universität Bochum, Deutschland, Tree-structured multi-dimensional Rank-Reduction Estimator (RARE) for MIMO channel estimation.

10. April 2003: Stavros Toumpis, Stanford University, USA, Capacity of ad hoc wireless networks and design issues.

11. April 2003: Kavé Salamatian, Université Pierre et Marie Curie, Paris, Frankreich, Traffic Matrix Estimation Techniques: Existing Techniques Compared and New Directions.

9. Mai 2003: John Prior, UTCS Neural Nets research group, University of Texas at Austin, USA, Eugenic Evolution for Combinatorial Optimization.

15. Mai 2003: Fabio Ricciato, INFOCOM, Universität Rom "La Sapienza", Italien, Definition and analysis of a dynamic model for differentiated protection with dual-fault resilience for connection-oriented networks (IP/MPLS, WDM).

16. Mai 2003: Stefan Resmerita, Technion, Haifa, Israel, A Multi-Agent Approach to Air Traffic Management.

19. - 23. Mai 2003: Gerhard Kramer, Mathematics of Communications Research Department, Bell Laboratories, USA, Mini-Course on Turbo-Codes and Iterative Decoding.

27. Mai 2003: Joint Source-Channel Coding: An Overview, Norbert Goertz, TU München, Deutschland

3. Juni 2003: Lutz Lampe, Universität Erlangen-Nürnberg, Deutschland, Robust Constant Envelope Transmission for Wireless Communications.

6. Juni 2003: Gerhard Franz, PhD, A. G. Franz Associates, LLC, Plainsboro, New Jersey, USA, RF over Fiber,

13. Juni 2003: Martin Weisenhorn, IBM Research, Zürich Research Laboratory, Schweiz, Review of Ultra-Wideband Radio Channel Modeling.

16. Juni 2003: Serap Savari, Bell Laboratories, Lucent Technologies, USA, Compression of Words over a Partially Commutative Alphabet.

27. Juni 2003: Edith Dusch, Siemens, Wien, Complexity-Analysis of VoIP Call Control Protocols SIP and H.323. Alexander Dusch, Victoria Volksbanken Versicherung, Wien, Implementation of IP-Tables on Linux for Secure Intranet-Servers, .

18. Juli 2003: Alan Duric, Global IP Sound, Stockholm, Schweden, Current Problems in Real-time Speech Transmission over IP.

8. September 2003: Stefan Mahlknecht, Institut für Computertechnik, TU Wien, Ultra Low Power Sensor Network.

15. September 2003: Alex Grant, University of South Australia, Adelaide, Australien, Capacity Computations for Discrete Memoryless Multiaccess Channels.

26. September 2003: Peter Winzer, Bell Laboratories, Holmdell, New Jersey, USA, High-Speed Optical Transmitters, Receivers, and Equalization.

7. Sonstiges / Miscellaneous

Internationales Seminar mit ETH Zürich und TU München über Mobilkommunikation

Digitale Signalverarbeitung / Digital Signal Processing

Advanced Multicarrier Systems for Wireless Communications
Contact: G. Matz *Partner:* FWF (Project P15156) Duration: 01.2002 - present

Nonlinear Speech Processing
Contact: W. Mecklenbräuker *Partner:* COST 277 Duration: 06.2002 - 12.2003

Christian Doppler Pilot-Lab for Design Methodology of Signal Processing Algorithms
Contact: M. Rupp *Partner:* Christan Doppler Society and Infineon Technologies
Duration: 06.2002 - 06.2004

Implementierung eines Tools zur Optimierung der Registernutzung eines Multiraten-Assembler-Programms
Contact: B. Wess, T.Zeitlhofer *Partner:* Infineon, München Duration: 10.2002 - 06.2003

Mobilkommunikation / Mobile Communications

Smart Antennas in Cellular Networks
Contact: W. Weichselberger *Partner:* Nokia Research Center, Helsinki
Duration: 08.1999 - 06.2003

Mobilkommunikation
Contact: E. Bonek *Partner*: mobilkom Austria Duration: 01.2001 - present

UMTS
Contact: T. Baumgartner *Partner:* mobilkom Austria Duration: 01.2001 - 09.2003

Advanced Network Radio Identification Equipment for Universal Mobile Communications (ANTIUM)
Contact: F. Hlawatsch *Partner*: EU (Project IST-2000-26222) Duration: 01.2001 - 12.2003

Toward Mobile Broadband Multimedia Networks
Contact: E. Bonek *Partner:* COST 273 Duration: 04.2001 - 04.2005

Semi-blind Signal Detection with Adaptive Antennas for CDMA
Contact: C. Pommer *Partner*: FWF (Project P14935) Duration: 06.2001 - 05.2003

Algorithmenentwicklung zur Optimierung von Mobilfunksystemen
Contact: W. Weichselberger *Partner:* Symena Duration: 03.2002 - present

Optische Nachrichtentechnik / Optical Communications

Multi-Aperture Imaging Interferometer (NBB)
Contact: O. Wallner *Partner:* EADS Astrium GmbH, TNO-TPD/NL, ESA-ESTEC/NL
Duration: 02.2001 - 04.2003

Quantum Communications in Space (QSpace)
Contact: W. Leeb, M. Pfennigbauer *Partner:* Inst. f. Experimentalphysik, Univ. Wien, ESA-ESTEC/NL
Duration: 08.2002 - 05.2003

Single-Mode Fibres for DARWIN
Contact: O. Wallner *Partner:* EADS Astrium GmbH, ART Photonics GmbH/D, ESA-ESTEC
Duration: 08.2002 - present

Advanced Fibre Coupling Technology (AFCT)
Contact: O. Wallner *Partner:* Contraves Space AG/CH, ESA-ESTEC/NL
Duration: 02.2003 – 10.2003

Seyringer, Christian **Kanalangepasste Trelliscodierung für zeitinvariante Übertragungskanäle mit Intersymbolinterferenz**

This thesis covers data transmission over frequency selective channels with additive white Gaussian noise.

Conventional codes designed for Intersymbol Interference (ISI) – free channels do not perform very well when applied to ISI-channels. Equalisation is the common way to reduce the Intersymbol Interference. Equalisation is not useful in certain cases e.g.: in case of channel coding decision feedback equalisation does not support soft-decision decoding.

This thesis proposes a simple robust Channel Matched Trellis Code to improve data transmission over a certain class of frequency selective channels. I focus on time invariant two-ray channels and assume that the channel is known to the transmitter. The encoding scheme uses a simple trellis code with two impulses per trellis section resulting in a rate 1/2 code. The amplitudes of the transmit pulses are matched to the impulse response of the channel such that the water filling principle for optimal transmit power distribution is approximated. At the receiver a Viterbi decoder operates on the combined encoder-channel trellis.

Due to the short constraint length of this trellis-encoder improved data transmission with very short decoding delay is achieved. Simulation results confirm that the new method outperforms comparable coded data transmission using Tomlinson-Harashima precoding.

Pospischil, Günther **Application development for UMTS**

The *Universal Mobile Telecommunications System (UMTS)* will only be successful if it offers *attractive applications*. There are many challenges for developers of such applications. The functionality of terminals is limited by processor power, memory, battery power, and especially the user interface. Wireless data transmission is quite error prone and the air interface in combination with required interworking functions is responsible for significant end-to-end transmission delays.

On the other hand, the *Open Service Access (OSA)* architecture, which has been developed in parallel with UMTS, offers many attractive features. It allows the combination of *Internet and telecommunications functionality* within a single application, access to different telecommunications and mobile networks is based on a standardized interface.

This thesis starts with providing an overview of relevant *Internet and mobile telecommunications technologies*. Based on this foundation, the possibilities of the *Mobile Internet* are discussed. Various service architectures are presented, focus is put on the UMTS service framework. Especially the topics *distributed object oriented programming, interface technologies* and *security* are discussed in detail.

In the next chapter, different *types of UMTS applications* are investigated. The novel idea of the thesis is the development of a common framework for real-time and non real- time applications, based on the Session Initiation Protocol (SIP) in conjunction with a concept for user and application profiles. Finally, a UMTS application prototype called *LoL@ (Local Location Assistant)* is presented. It provides an electronic guide for tourists in Vienna, including navigation, hypertext and multimedia information. LoL@ has been designed under the constraints of current terminals and mobile communications systems, hence it provides several work around mechanisms for these limitations.

The last part of the thesis deals with the *performance evaluation of different data transmission systems and protocols*. The performance of conventional Internet protocols for mail, file transfers and multimedia (hypertext,streaming) is compared with a SIP-based unified communications mechanism. The evaluation is based on measurements of different transmission systems (14.4 kbit/s modem, V.90 modem, GSM/GPRS) and system simulations for GPRS.

It turns out that GSM/GPRS is suitable for applications with limited multimedia functionality. However, it is necessary that application designers are aware of the limitations of GSM/GPRS (especially regarding delays and varying throughput). UMTS will reduce these limitations, performance that is at least equivalent to currently used V.90 or ISDN connections can be expected.

The last part of the thesis provides summary of the results, conclusions and some ideas for future developments and research topics.

Liang Ming **A tool for power-density prediction of radiopropagation in urban environments**

The ability to predict transmission loss or field strength distribution is crucial for determining coverage in planning personal communication systems. Previous transmission loss prediction methods have considered specular reflection and diffraction of electromagnetic waves by and over buildings between the base station and the mobile terminals. These phenomena are of great importance in urban areas where there are many high buildings. But diffuse scattering is usually neglected.

In urban environments, there are many irregularities such as windows, balconies, stucco, and so on in the outside building walls, and that are comparable with the wavelength of mobile communication (about 16.7cm

for 1.8GHz). Hence we can suppose that the surface variations of most outside building walls are more than the threshold (2.79 cm for 1.8GHz and 45° incidence angle) at which roughness warrants consideration, real building walls can be thought as *rough surfaces*. Therefore it is reasonable to simplify the radio-wave propagation in urban environments to the electromagnetic scattering problem. According to this simplification, and utilizing advanced mathematical methods and three-dimensional (3D) graphics techniques, it was possible to develop a practical 3D prediction tool for urban areas, running on a PC.

This thesis presents this promising and practical transmission loss prediction tool based on received radio power density. It allows to simulate very fast the average transmission loss (or mean field strength) distribution in urban radio propagation environments. The technique uses a 3D optical propagation model based on optical radiant flux transfer method (known to the computer graphics community as "radiosity") and a simplified city-information database. The associated software product named "RadioPower" (version 1.10) has been developed with MSVC++ 5.0 under Windows 9X/NT/2000. It consists of pre-processing, field-strength simulation, 3D post-processing and visualization. There are about 17000 lines of source code. If the PC has 512MB memory and a powerful CPU (Pentium 1k), RadioPower allows to process the entire 3D map data of an European city, and to simulate and visualize the average transmission loss distribution over all the (wall and road) outside surfaces and the interesting points at one time with acceptable time-consumption and engineering-precision.

The software offers much convenience in the actual design. As an sample, I have realized the simulation of average transmission loss distribution in the whole urban environment of Vienna´s fourth district around Fakultät für Elektrotechnik und Informationstechnik. That utilizes a detailed city-map which contains location, shape and height of buildings. The simulated results are demonstrated and visualized in RadioPower (Typical run-time was about 10 minutes on a PC with the following specification: Windows 98/P-II 350MHz CPU/128M RAM). Comparison between the simulated results and the data actually measured previously demonstrate good coincidence (less than 5dB standard deviation of the error), which is an indication of the validity of RadioPower's model and algorithms.

Kopsa, Klaus **Space-Time Processing for UMTS/TDD**

The goal of the EU-funded project ANTIUM was to develop a monitoring device for UMTS and DVB-T networks which allows to assess the interference situation present. The information provided by this device should enable operators to optimise their network. More specifically, forUMTS/TDD, to which this thesis is restricted, algorithms had to be developed which read the so-calledbroadcast channels (BCHs) of as many surrounding base stations as possible. Since the ANTIUM device is equipped with multiple antennas at the receiver, space-time signal processing can beneficially be used. The task of reading the BCHs splits up into *synchronisation*, *channel estimation*,and *data detection*.

The first step of the synchronisation stage is scanning the received data for the presence of synchronisation codes to determine the number of impinging base station signals. Subsequently, the temporal locations of the BCHs and information on the used training sequences (basic midambles) and scrambling codes are extracted. The three synchronisation algorithms presented in this thesis are based on a binary hypothesis test which uses a generalised likelihood ratio to obtain a decision statistic for the presence of synchronisation codes. Averaging over several frames turns out to improve this decision statistic considerably.

Since the composition of the midambles offered by UMTS/TDD for the purpose of channel estimation depends on the unknown number of data channels present, this composition has to be estimated prior to channel estimation. For this estimation task, two different methods are presented. Using the estimated midambles, multiuser channel estimation based on the MMSE principle can then be performed. We also develop a modified channel estimation technique with interference cancellation.

Knowledge of the channel impulse responses enables the data detection stage to equalise the channel and to recover the data. It turns out that for the conventional space-time MMSE filter, the required correlation matrix cannot be estimated with sufficient accuracy. The solution we propose is to explicitly calculate the correlation matrix instead of estimating it. For this task, we have to detect the data channels present and estimate their respective transmit amplitudes. Since this can be done with greatest accuracy for the strongest base station, we use an interference cancellation approach.

We finally investigate the influence of synchronisation and channel estimation errors on the performance of the detection stage. Simulations of the overall receiver system yield mostly satisfactory results, but they also show that the accuracy of channel estimation has a strong impact on data detection performance.

Kehrer, Daniel **40 Gb/s High Speed Circuits in Standard CMOS Technology**

Todays serial data communication systems operate at throughputs between 10 Gb/s and 40 Gb/s. Up to now communications ICs operating at such high speeds were engineered using GaAs, InP or SiGe bipolar technologies. Heavy emphasis was placed on finding the right match between circuit techniques and fabrication technology.

This thesis demonstates CMOS to be a viable alternative for broadband circuit design at 10+ Gb/s. The approach is very economical because of the lower production costs, of higher yield and integration density. Recent achievements in CMOS multiplexer and demultiplexer design which fully exploit the speed potential of a 0.13 µm standard CMOS technology are presented. Advanced circuit techniques and a state-of-the-art fabrication pro-

cess are combined to extend speed limits.

As an introduction serial data communication building blocks are presented and multiplexer/demultiplexer architectures are discussed. Block diagrams and timing charts show the functionality of data latches, flip-flops, frequency dividers and multiplexer/demultiplexer architectures. Understanding the MOS transistors parasitics is important for high-speed design. The circuits treated in this thesis are current mode logic (CML) designs, since there is a speed penalty of static CMOS logic compared to CML.

A 40 Gb/s multiplexer in CMOS is presented for the first time. To reach this speed the 2:1 multiplexer uses shunt and series inductive peaking which nearly doubles the bandwidth. A companion 40 Gb/s demultiplexer IC is also presented. Measured eye diagrams of both ICs demonstate their performance.

The design procedures elaborated in the present thesis are suitable to achieve increased data transmission speed, to enable integration of complex functions on single chips and, ultimately, to reduce the costs for highly integrated communication systems.

Baumgartner, Thomas **Smart Antenna Strategies for the UMTS FDD Downlink**

In this thesis I present methods for improving the downlink capacity (number of served users) of the Frequency Division Duplex (FDD) mode of the Universal Mobile Telecommunication System (UMTS) with the help of an antenna array at the base station. In a Code Division Multiple Access (CDMA) system like UMTS, the performance gain of methods relying on capabilities in the mobiles that are not available in all mobiles, degrades with the number of mobiles that cannot support these methods. Therefore, I focus on smart antenna methods that do not need any capabilities in the mobiles beyond the capabilities of current UMTS terminals that are built according to Release 99 of the UMTS specification.

After presenting the main features of the physical layer of UMTS, I introduce potential

smart antenna strategies. Two of the presented strategies, the logic cell method and the switched beam method are fixed beam methods that place a fixed grid of beams over the coverage area. In contrast to the fixed beam methods, user specific beamforming methods, form an individual beam for each user.

For the presented methods I discuss also implementation issues like the optimum orientation of the antenna array or the necessary changes to the radio resource management algorithms like admission control and scrambling code assignment. Furthermore I show that the for the switched beam method essential reporting of measurements, concerning the best beam to serve a certain user, are not supported by the specification of the protocol of the interface between base station and radio network controller in the current UMTS standard (Release 5 from March 2003). The reporting of this information is necessary for the switched beam method, as only the radio network controller is able to tell the mobile on which beam the data is sent, i.e. which pilot channel is the phase reference for the data.

Considering runtime, the complexity and the availability of required link level results, I decided to develop a static system-level simulator for evaluating the different smart antenna strategies. Due to its static nature a static system-level simulator is not able to simulate dynamic processes like packet switched services. Therefore, I assume for my evaluations that the system is loaded with users requesting a 144kbit/s circuit switched data service. However, a system that performs poor if loaded with circuit switched traffic due to bad setting of the radio parameters is supposed to perform also poorly if loaded with packet switched traffic. The same holds for well performing systems.

Using this simulator I evaluate the optimum number of beams per 120 sector for the fixed beam methods and show that the optimum beam number depends on both the chosen method and the radio environment. For the logic cell method the optimum number of beams per sector is in the range from two to five, whereas the switched beam method performs best with five to seven beams per sector.

The use of four element uniform linear antenna arrays at the base station can improve the downlink capacity of UMTS FDD by up to 175%. For the calculation of proper transmit weights, user specific beamforming needs much more signal processing at the base station than fixed beam methods. But the capacity achieved with user specific beamforming is not significantly higher than the capacity achieved with fixed beam methods. Therefore I conclude that fixed beam methods are the methods to choose for boosting the downlink capacity of UMTS.

If the protocol of the interface between base station and radio network controller in future

releases of the UMTS standard will include the reporting of the measurements needed for the switched beam method, I advice to use the switched beam method because this method provides a up to 16% higher system capacity than the logic cell method. If the protocol of the interface between base station and radio network controller will not be adapted to support the switched beam method, I suggest to use the logic cell method for improving the capacity of the UMTS FDD downlink.

Pauer, Martin **Return-to-zero coding in optical intersatellite links**

Future satellite-based networks in low earth orbits (LEOs) will employ optical intersatellite links (OISLs) to accommodate the ever increasing demand for transmission capacity. This work presents an analysis of a semiconductor laser diode based system for optical data transmission in the Gbit=s range between satellites operating at a wavelength of 1,55μm. Special emphasis is placed on optical amplifiers in the transmitter and receiver, as well as on advantages brought by return-to-zero (RZ) coding over the more common non-return-to-zero (NRZ) modulation format. The latter will be discussed using an optically preamplified direct detection receiver.

Concentrating first on the transmitter, my studies cover the properties of erbium doped fiber amplifiers (EDFAs), as they are encountered as booster amplifiers in free-space laser communication terminals. Treating the gain dynamics of an EDFA theoretically, it is demonstrated that the amplifier is average-power limited provided that the data rate lies above a certain threshold rate. The threshold increases with EDFA pump power; in case of optical power amplifiers, it is found to be typically around 0,5Mbit/s. A pulse train at a repetition rate below this threshold appears considerably distorted at the output of the amplifier. For pulse frequencies lying orders of magnitude below the threshold rate, the leading edge of each pulse is amplified at almost the small signal gain of the EDFA, which can produce exceptionally high optical peak powers. In my experiments, a peak power of 28dBm was measured using an optical preamplifier rated for an average output power of 15dBm; numerical calculations promise a peak power as high as 43dBm in case of a power amplifier, rated for an average output power of about 30dBm. A possible application of my findings is the generation of pulses for acquisition purposes, i.e. mutual alignment of transmit and receive telescope, without the need for a separate (high power) beacon laser.

Investigations of the sensitivity of optically preamplified direct detection receivers show that RZ coding yields a sensitivity improvement of about 1 - 2dB compared to non-return-to-zero (NRZ) coding. This improvement corresponds to a reduction of the required average input power. RZ coding is at present the technically most feasible way of achieving receiver sensitivities close to the quantum limit (which constitutes the fundamental performance limit). This is highly desirable, e.g. in free space links, due to limited resources onboard a satellite. By simulations, it is shown that a pulse duty cycle of 0,3 is optimum with respect to a sensitivity gain over NRZ. Both my simulations and measurements reveal that, in case of RZ coding, the receiver is more tolerant regarding suboptimum parameters, such as optical and electrical filter bandwidth. Taking into account the finite extinction ratio of commercially available optical modulators, I did identify the modulation of a pulse train as the preferred method to generate an RZ coded waveform in practical implementations. In this case, the sensitivity improvement over NRZ coding is unaffected by decreasing modulator extinction.

Intense background sources illuminating the receiver seriously can degrade the performance in free space links. A general advantage of optically preamplified receivers is the excellent suppression of background noise due to spatial filtering. Even with the telescope looking directly into the sun, a sensitivity penalty of less than 1dB is found from simulations.

DIPLOMARBEITEN / DIPLOMA THESES

1.10.2002 - 30.9.2003

ALLRAM, M.	System verification of UMTS baseband functions with high level models. 2003.
BARTOSIK, O.	Sprachanalyse und –synthese mit Hilfe von MATLAB. 2003.
BASILE, M.	Adaptive Channel estimation. 2003 (Erasmus).
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CARRIERI, V.	Adaptive equalizer structures for BLAST transmission utilizing polyphase filters. 2003 (Erasmus).
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DIEMBERGER, C.	Interneteinbindung über Mikrowellenrichtfunk. 2003.
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ENGL, M.	Parasitic extraction for monolithic integrated inductors. 2003.
GIL FERRAS, A.	Efficiency of channel estimation if beam pointing is used in UMTS. 2002. (Erasmus).
GOLL, B.	Experimentelle Untersuchung der Modenfilterung mit Glasfasern im mittleren Infrarot. 2003.
HALLER, E.J.	TCP/Ipim wireless-and-wired networks. 2003.
HARTMANN, M.	Multipulse multicarrier systems for wireless communications. 2003.
JUSIF, L.	Interleaver design for minimum latency turbo coding. 2003.
KROYER, T.	A waveguide high order mode reflectometer for the large hadron collider beam-pipe. 2003.
LECHNER, G.	Convergence of the sum-product algorithm for short low-density parity-check codes. 2003.
MOUSTAFA, M.	HF-Baugruppen eines Senders für Verkehrstelematikanwendungen im 5,8 GHz Bereich. 2003.
POVOLNY, R.	Entwicklung einer Empfängerbaugruppe für den 5,8 GHz Bereich. 2003.

BÜCHER UND BUCHBEITRÄGE / BOOKS AND BOOK CHAPTERS

1.10.2002 - 30.9.2003

HLAWATSCH, F., TAUBÖCK, G., TWAROCH, T., Covariant time-frequency analysis. In: Wavelets and Signal Processing, ed. L.Debnath, Boston (MA): Birkhäuser, 2003, pp.177-231.

KOIVUNEN, V., LAURILA, J., BONEK, E., Blind methods for wireless communication receivers. Kap.12 in: W.R.Stone(ed.): Review of radio science 1999-2002, ISBN 0-471-26866-6, pp.247-273

MATZ, G., HLAWATSCH, F., Linear time-frequency filters: On-line algorithms and applications. In: A.Papandreou-Suppappola (Ed.) Applications in Time-Frequency Signal Processing, CRC Press 2003, ISBN 0-8493-0065-7, Ch.6, pp.205-271.

RUPP, M., BURG, A., Algorithms for adaptive equalization in wireless applications. In: BENESTY, J., HUANG, Y. (eds.) Adaptive Signal Processing: Application to real-world problems. Springer 2003, ISBN 3-540-00051-8, pp. 249-281.

VERÖFFENTLICHUNGEN / PUBLICATIONS

1.10.2002 - 30.9.2003

ADJOUDANI, A., BECK, E.C., BURG, A.P., DJUNIC, G.M., GVOTH, T.G., HAESSIG, D., MANJI, S., MILBRODT, M.A., RUPP, M., SAMARDZIJA, D., WILKUS, S.A., WOLIANSKY, P.W., Prototype experience for MIMO BLAST over third generation wireless system. IEEE Journal Selected Areas in Communications. Vol.21 (2003), pp.440-451.

ALTER, K., RANK, E., KOTZ, S.A., TOEPEL, U., BESSON, M., SCHIRMER, A., FRIEDERICI, A.D., Affective encoding in the speech signal and in event-related brain potentials. Speech Communication, vol.40 (2003), pp.61-70.

ARTES, H., HLAWATSCH, F., Fast iterative decoding of linear dispersion codes for unknown MIMO channels. 36th Asilomar Conference Signals, Systems, Computers, Nov. 3-6, 2002, Pacific Grove, CA, USA, pp.284-288.

ARTES, H., HLAWATSCH, F., Space-time matrix modulation: extension to unknown doubly selective MIMO channels. IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP-2003), Hong Kong, April 6-10, 2003, pp. IV-41 – IV-44.

ASCHBACHER, E., RUPP, M., Identification of a nonlinear power-amplifier L-N-L structure for pre-distortion purposes. 14 th IEEE International Symposium on personal, Indoor and Mobile Radio Communications, Sept. 7-10, 2003, Beijing, CD.

ASCHBACHER, E., RUPP, M., Modelling and identification of a nonlinear power-amplifier with memory for nonlinear digital adaptive pre-distortion. IEEE SP Workshop on Signal Processing Advances in Wireless Communications (SPAWC), June 15-18, 2003, Rom, CD.

BAKALSKI, W., ILKOV, N., DERNOVSEK, O., MATZ, R., SIMBÜRGER, W., WEGER, P., SCHOLTZ, A.L., 5-6.5GHz LTCC power amplifier module with 0.3W at 2.4V in Si-bipolar. Electronics Letters, vol.39 (2003), No.4, pp.375-376.

BAKALSKI, W., KNAPP, H., SIMBÜRGER, W., SCHOLTZ, A.L., Baluns for microwave applications. Part 1. VHF Communications, vol. 34(2002), pp.181-187.

BAKALSKI, W., KNAPP, H., SIMBÜRGER, W., SCHOLTZ, A.L., Baluns for microwave applications. Part 2. VHF Communications, vol. 34(2002), pp.202-214.

BELANOVIC, P., HOLZER, M., MICUSIK, D., RUPP, M., Design Methodology of Signal Processing Algorithms in Wireless Systems, International Conference on Computer, Communications and Control Technology, Orlando, Florida, 31.7.-2.8.2003, pp. 288-291.

BELANOVIC, P., HOLZER, M., RUPP, M., A Consistent Design Methodology to Meet SDR Challenges, Wireless World Research Forum, Zurich 1.-2.7.2003.

BÖLCSKEI, H., HLAWATSCH, F., KUBIN, G. (eds.), From signal processing theory to implementation. Special Section in Signal Processing, vol.83 (2003), pp. 1353-1444.

BÖLCSKEI, H., WEINRICHTER, H., An overview of coding techniques for fading channels using multiple antenna elements. e&i 119.Jg(2002), pp.376-380.

BONEK, E., Space – the frontier in cellular mobile radio. NTT DoCoMo Technical Journal, vol.4(2002), No.3, pp.4-5.

BRATANOV, P., BONEK, E., Mobility model of vehicle-borne terminals in urban cellular systems. IEEE Transaction on Vehicular Technology, vol.52 (2003), pp.947-952.

BURG, A., BECK, E., RUPP, M., PERELS, D., FELBER, N., FICHTNER, W., FPGA implementation of a MIMO receiver front-end for the UMTS downlink. 2002 Int. Zürich Seminar on Broadband Communications, Feb.19-21, 2002, Zürich, Schweiz, pp.8-1 – 8.6.

FRANZ, S., MITRA, S.K., DOBLINGER, G., Frequency estimation using warped discrete Fourier transform. Signal Processing, vol.83 (2003), pp.1661-1671.

GERDENITSCH, A., JAKL, S., TOELTSCH, M., NEUBAUER, T., Intelligent algorithms for system capacity optimization of UMTS FDD networks. Fourth International Conference on 3G Mobile Communication Technologies, London June 25-27, 2003, pp. 222-226.

GRITSCH, G., WEINRICHTER, H., RUPP, M., Understanding the BER-performance of space-time block codes, IEEE SP Workshop on Signal Processing Advances in Wireless Communications (SPAWC), Rome, Italy, June 15-18, 2003, CD.

HACKL, S., BÖCK, J. RITZBERGER, G., WURZER, M., SCHOLTZ, A.L., A 28-GHz monolithic integrated quadrature oscillator in SiGe bipolar technology. IEEE J. of Solid-State Circuits, vol.38 (2003), pp.135-137.

HERDIN, M., ÖZCELIK, H., HOFSTETTER, H., BONEK, E., Linking reduction in measured MIMO capacity with dominant-wave propagation. 10th International Conference on Telecommunications ICT'03. Feb. 23-March 1, 2003, Papeete, Tahiti, pp.1526-1530.

HLAWATSCH, F., MATZ, G., JACHAN, M., Robuston methods for stable statistical signal processing: Principles and application to nonstationary signal estimation. Proc. IEEE ICASSP-2003, Hong Kong, April 6-10, 2003, vol. VI, pp.649-652.

JACHAN, M., HLAWATSCH, F., MATZ, G., Stable adaptive nonstationary signal detection based on the robuston scheme. Proc. 12th IEEE Workshop on Statistical Signal Processing, St.Louis (MO), Sept.29-Oct.1, 2003, pp. 601-604.

JACHAN, M., MATZ, G., HLAWATSCH, F., Time-frequency-autoregressive random processes: Modeling and fast parameter estimation. Proc. IEEE ICASSP-2003, Hong Kong, April 6-10, 2003, vol.VI, pp.125-128.

KEHRER, D., STEINLESBERGER, G., AUFINGER, K., TISCHER, H., WOHLMUTH, H.-D., SIMBÜRGER, W., SCHOLTZ, A.L., Prospects of microstrip waveguides in aluminium and copper metallization for high-frequency applications. Revista da sociedade Brasileira de Telecomunicacoes, vol.18 (2003), pp.1-9.

KEHRER, D., WOHLMUTH, H.D., KIENMAYER, C., SCHOLTZ, A.L., A 1V monolithic transformer-coupled 30-Gb/s 2:1 multiplexer in 120nm CMOS. IEEE International Microwave Symposium, Philadelphia, June 8-13, 2003, pp.2261-2264.

KEHRER, D., WOHLMUTH, H.D., KNAPP, H., WURZER, M., SCHOLTZ, A.L., 40-Gb/s 2:1 multiplexer and 1:2 demultiplexer in 120nm standard CMOS. IEEE International Solid-State Circuits Conference, San Francisco, Feb.9-13,2003, pp.344-345.

KOPSA, K., ARTES, H., MATZ, G., HLAWATSCH, F., Space-time algorithms for multiuser channel estimation in the downlink of UMTS/TDD. IEEE International Conference of Communications (ICC) 2003, Anchorage 11.5.-15.5. 2003, Alaska pp.2406-2410.

KOPSA, K., MATZ, G., ARTES, H., HLAWATSCH, F., Bit error rate estimation for a joint detection receiver in the downlink of UMTS/TDD. IST Mobile & Wireless Comm. Summit 2003, Aveiro (Portugal), June 15-18, 2003, pp.256-260.

KOPSA, K., MATZ, G., ARTES, H., HLAWATSCH, F., Space-time synchronization algorithms for UMTS/TDD systems with strong co-channel interference. IEEE Globecom 2002, Taipei, Taiwan, Nov. 17-21, 2002, pp.254-258.

KUCHAR, A., TANGEMANN, M., BONEK, E., A real-time DOA-based smart antenna processor. IEEE Trans. On Vehicular Technology, vol.51 (2002), pp.1279-1293.

MATZ, G., Characterization of non-WSSUS fading dispersive channels. IEEE Int. Conference on Communications (ICC), Anchorage (AK), May 11-15, 2003, pp.2480-2484.

MATZ, G., Doubly underspread non-WSSUS channels: Analysis and estimation of channel statistics. IEEE SP Workshop on Signal Processing Advances in Wireless Communications (SPAWC), Rome, Italy, June 15-18, 2003, Rom, CD.

MATZ, G., HLAWATSCH, F., Wigner distributions (nearly) everywhere: time-frequency analysis of signals, systems, random processes, signal spaces, and frames. Signal Processing, vol.83 (2003), pp. 1355-1378.

MATZ, G., RAIDL, A., Robust detection of nonstationary random signals belonging to p-point uncertainty classes. IEEE Int. Conference Acoustics, Speech, and Signal Processing, Hong Kong, April 6-10, 2003, pp.641-644.

MATZ, G., Uncertainty and concentration inequalities for nonstationary random processes and time-frequency energy spectra. IEEE 36th Asilomar Conference on Signals, Systems and Computers, Nov. 3-6, 2002, Monterey, CA, USA, pp. 1571-1575.

MOHAMAD, H., WEISS, S., RUPP, M., MMSE limitations for subband adaptive equaliser. IEEE 36th Asilomar Conference on Signals, Systems and Computers, Nov. 3-6, 2002, Monterey, CA, USA, pp.1233-1237.

ÖZCELIK, H., HERDIN, M., HOFSTETTER, H., BONEK, E., A comparison of measured 8x8 MIMO systems with a popular stochastic channel model at 5.2GHz. 10th International Conference on Telecommunications ICT'03. Feb. 23-March 1,2003, Papeete, Tahiti, pp.1542-1546.

ÖZCELIK, H., HERDIN, M., HOFSTETTER, H., BONEK, E., Capacity of Different MIMO systems based on indoor measurements at 5.2GHz. 5th European Personal Mobile Communications Conference, Glasgow, April 22-25, 2003, pp.463-466.

ÖZCELIK, H., HERDIN, M., PRESTROS, R., BONEK, E., How MIMO capacity is linked with single element fading statistics. International Conference on Electromagnetics in Advanced Applications (ICEAA'03), Sept. 8-12,2003, Turin, pp.775-778.

ÖZCELIK, H., HERDIN, M., WEICHSELBERGER, W., WALLACE, J., BONEK, E., Deficiencies of „Kronecker" MIMO radio channel model. ELECTRONICS LETTERS, Vol. 39 (2003), pp. 1209-1210.

PAUER, M., WINZER, P.J., Impact of extinction ratio on return-to-zero coding gain in optical noise limited receivers. IEEE Photonics Technology Letters vol.15 (2003), pp.879-881.

PFENNIGBAUER, M., LEEB, W.R., Optical satellite communications with Erbium doped fiber amplifiers. Space Communications, vol.19(2003), pp.59-67.

RUPP, M., BURG, A., BECK, E., Rapid Prototyping for Wireless Designs: The Five-Ones Approach, Signal Processing vol.83, (2003), pp.1427-1444.

RUPP, M., MECKLENBRÄUKER, C.F., Improving Transmission by MIMO Channel Structuring, International Conference of Communications (ICC) 2003, Anchorage 9.5.-16.5.2003, Alaska pp. 3066-3070.

RUPP, M., MECKLENBRÄUKER, C.F., On extended Alamouti schemes for space-time coding. IEEE 5th International Symposium on Wireless Personal Multimedia Communications, Oct. 27-30, 2002, Hawai, USA, pp. 115-119.

RUPP, M., On the influence of uncertainties in MIMO decoding algorithms. IEEE 36th Asilomar Conference on Signals, Systems and Computers, Nov. 3-6, 2002, Monterey, CA, USA, pp. 570-574

SCHAFHUBER, D., MATZ, G., HLAWATSCH, F., Adaptive Wiener filters for time-varying channel estimation in wireless OFDM systems. Proc. IEEE ICASSP-2003, Hong Kong, April 6-10, 2003, vol.IV, pp.688-691.

SCHAFHUBER, D., RUPP, M., MATZ, G., HLAWATSCH, F., Adaptive identification and tracking of doubly selective fading channels for wireless MIMO-OFDM systems. IEEE SP Workshop on Signal Processing Advances in Wireless Communications (SPAWC), Rome, Italy, June 15-18, 2003, CD.

SCHOLTZ, A.L., KEHRER, D., TIEBOUT, M., WOHLMUTH, H.-D., KNAPP, H., WURZER, M., PERNDL, W., REST, M., KIENMAYER, C., THÜRINGER, R., BAKALSKI, W., SIMBÜRGER, W., CMOS and SiGe bipolar circuits for applications up to 110 GHz. e&i, 120.Jg.(2003), pp.271-275.

STRASSER, M.M., WINZER, P.J., NAPOLI, A., Emulating ETDM receivers by OTDM receivers for high speed system measurements. Proc. Of the 15th Annual Meeting of the IEEE Lasers and Electro-Optics Society (LEOS), Glasgow, Scotland, Nov. 10-14, 2002, pp.778-779.

WALLNER, O., LEEB, W.R., FLATSCHER, R., Design of spatial and modal filters for nulling interferometers. Proc. of the SPIE, vol. 4838 (2003), pp. 668-679.

WALLNER, O., LEEB, W.R., WINZER, P.J., Minimum length of a single-mode fiber spatial filter. J. Opt.Soc.Am.A, vol.19(2002), pp. 2445-2448.

WEICHSELBERGER, W., HUGL, K., Optimum power allocation for transmit diversity in mobile communications. 10th International Conference on Telecommunications ICT'03. Feb. 23-March 1,2003, Papeete, Tahiti, pp.1555-1560.

WINZER, P., LEEB, W.R., Space-borne optical communications – a challenging reality. Proc. of the 15th annual Meeting of LEOS 2, Glasgow, Nov.10-14 (2002), pp.393-394.

WINZER, P.J., LEEB, W.R., Space-borne optical communications – a challenging reality. Proc. Of the 15th Annual Meeting of the IEEE Lasers and Electro-Optics Society (LEOS), Glasgow, Scotland, Nov. 10-14, 2002, pp.393-394.

WOHLMUTH, H.D., KEHRER, D., THÜRINGER, R., SIMBÜRGER, W., A 17GHz dual-modulus prescaler in 120nm CMOS. IEEE Radio Frequency Integrated Circuits Symposium, Philadelphia, June 8-13, 2003, pp.479-482.

ZEITLHOFER, T., DALLINGER, R., GRYSKA, H., WESS, B., Data register minimization for an application-specific DSP. International signal Processing Conference, Dallas, March 31-April 3, 2003, CD

ZEITLHOFER, T., WESS, B., List-coloring of interval graphs with application to register assignment for heterogeneous register-set architectures. Signal Processing, vol.83 (2003), pp.1411-1425.

ZEITLHOFER, T., WESS, B., Optimum register assignment for heterogeneous register-set architectures. IEEE Int. Symposium on Circuits and Systems, Bangkok, May 25-28, 2003, pp. III-252 – III-255.