THE ICT STRATEGY OF THE TECHNISCHE UNIVERSITÄT MÜNCHEN

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The Technische Universität München (TUM) realigns its information and communication technology (ICT) strategically in co-operation with the Leibniz Supercomputing Centre (LRZ). This realignment is accomplished under guidance of the Chief Information Officer (CIO) in accordance with the overall strategy of TUM by means of closely interconnected projects in the areas of organisation, campus management, eLearning and ICT infrastructure. Basis of success are standardisation of the organisational and technical solutions as well as the university-wide integration of all groups involved. Whilst processes and technology are harmonised, responsibility for research, teaching and contents remains with the different organisational units. This paper motivates the strategy and gives an overview over the resulting organisational and technical projects and measures.

1. Overview

We start with a short introduction of our university. After that we describe the motivation and background of the ICT strategy of TUM and describe our overall goals. Section 5 describes the organisational framework of ICT. Section 6 gives an overview over the existing ICT systems at TUM and motivates the architecture chosen. Section 7 describes the projects initiated, partly giving detailed information of selected projects. The paper concludes with our current status, an overview of the chances and risks of the project and a short summary. This article is based on a previous paper [Bor07].

2. Short description of the university

TUM ranks among the top universities nationally and internationally. Since the 90's of the last century the TUM is pursuing the goal to strengthen its autonomy. Guidelines for the transformation are subsidiarity, personal responsibility and separation of power. The current statute of TUM served as a role model for the mandatory order of Bavarian universities, pursuant to the new Bavarian Universities Act of 2006 (Bayerisches Hochschulgesetz). In 2006 TUM got awarded as one of three German elite universities out of all German universities.

The TUM is the only university of technology in Bavaria. Its 20,000 students, 400 full-time professors and approximately 8,800 scientific and non-scientific employees are spread over three main locations, which are Munich City Centre, Garching and Weihenstephan (near Freising). It also includes the university hospital Rechts der Isar as a legally and economically independent unit.

A distinctiveness of TUM among other German universities is that TUM does not have its own computing centre. For all universities in Munich and surrounding areas this function is fulfilled by Leibniz Supercomputing Centre of the Bavarian academy of the sciences (LRZ).

3. Background and motivation of the project

The achievements of universities in administration, research, teaching and further training can substantially be improved by efficient use of ICT in the sense of the "Digital University". After a period of decentralisation during the 80's and 90's motivated by technology, it is about time to centralise the ICT more strongly in order to face the challenges lying ahead.

The needs of individual, organisational units have adjusted to a large extent to the technical level - at least with regards to basic ICT services. Provided that the computing centre offers appropriate services, department servers are no longer needed due to the availability of decentralised, fast communication networks. For example it is no longer reasonable to operate email-, web-, file-, backup-servers etc. by means of valuable (scientific) staff members on the chair or faculty level, if more reliable and more secure services can be obtained from the computing centre.

In the business perspective the Bologna Process multiplies the number of study-accompanying exams and leads to a higher throughput of students. The execution of application- and aptitude-tests (instead of having the students assigned by a national agency) necessitates completely new business processes. Increasing interdisciplinary courses of studies aggravate the administration of the faculties. According to a doubled number of school-graduates in the future due to the abbreviation of years of study in grammar school, as well as to a government intended general increase of the student's contingent among school graduates and more international students, the number of students continues to rise. With the introduction of tuition fees the expectations of the students will rise at the same time. Another field of activity to be strengthened within universities will be external further education.

The reorganisation in the context of the Bologna Process affords an opportunity to standardise the condition of study beyond subject boundaries in such a way that an ICT support for the exam administration can be made available centrally with a reasonable effort. [Bod05]

The extension of interdisciplinary co-operation in research and teaching as well as modified methods of operation regarding the production, dissemination and storage of knowledge produces new requirements for ICT. Last but not least economical (e.g. shortage of funds, global budgets, cost performance calculation, projects funded by third parties with own safety requirements) and legal (e.g. Telecommunication Surveillance Act (TKÜV), the Bavarian IuK coordination directive, data security, procurement regulations etc.) constraints impose further requirements for the ICT of the university.

The only way to meet all the mentioned requirements is a coordinated and professional approach. Furthermore there are expectations to achieve economic advantages by the centralisation of ICT, e.g. by economies of scale or by the reduction of the technological and professional redundancy. The discharge of scientific staff from the duties of the system administration will lead to an improvement of research and teaching. On the other hand the real costs of the ICT will be made transparent by the integration desired.

4. Strategic goals and guidelines, targeted models

The ICT strategy of TUM aligns with the overall strategy of TUM. One goal of the ICT strategy of TUM is the provision of a customer-friendly and smoothly integrated ICT infrastructure for research, teaching and administration. The responsibility for contents and

processes remains with the faculties and central organisational units. The tasks of computing centres should be shifted to LRZ as far as possible.

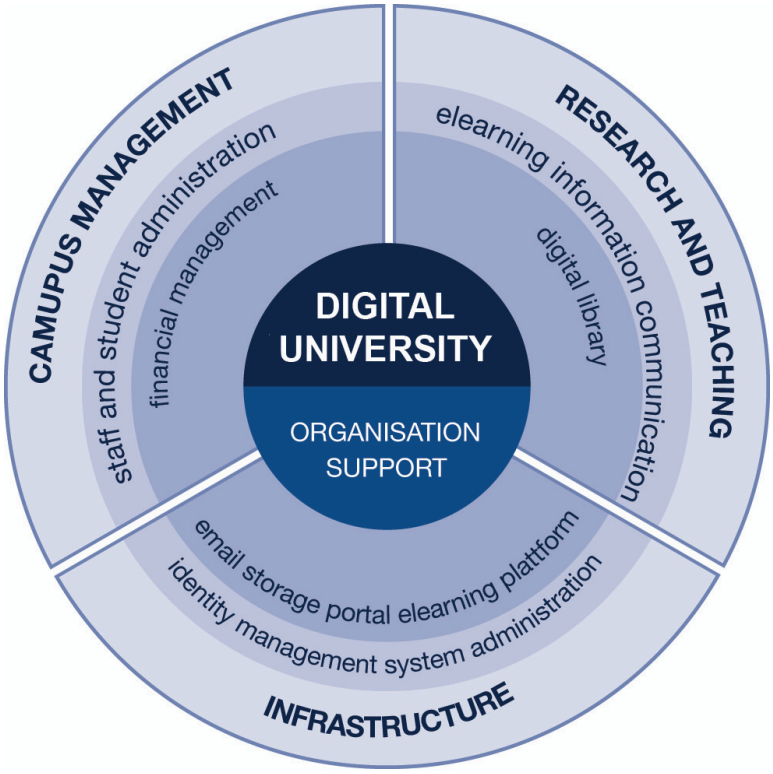

Figure 1: The model of the Digital University

Leitmotif of the ICT strategy is the "Digital University" (see Fig. 1). Accordingly, four main fields of action arise:

- Organisation: Under the guidance of the CIO together with the representatives of the faculties and of the central organisational units who are responsible for ICT, responsibility and competencies for the ICT are specified.
- Research and teaching: This includes a central system for eLearning, digital libraries and web portals.
- Campus management: The systems of campus management cover personnel and student administration, financial accounting, real estate administration and exam and course administration.
- ICT infrastructure: Forms the technical basis for the Digital University. It consists of hardware, communication networks, system software and central services e.g. email, storage, backup, archiving, document management, and identity management.

Altogether an integrated infrastructure is to be developed. It offers central ICT services needed from a majority of the members of the university and it reduces redundancies in technology and data. For the centrally offered services a service desk is available as the single point of contact. For every service offered the responsibility for operation and further development is defined.

The different (non-ICT) units can still operate own systems, especially in the area of research. There is no obligation to use the central systems; however the operation of certain technical

and organisational interfaces may be required. The additional costs resulting from the operation of own systems remain with the units.

5. Organisational structure

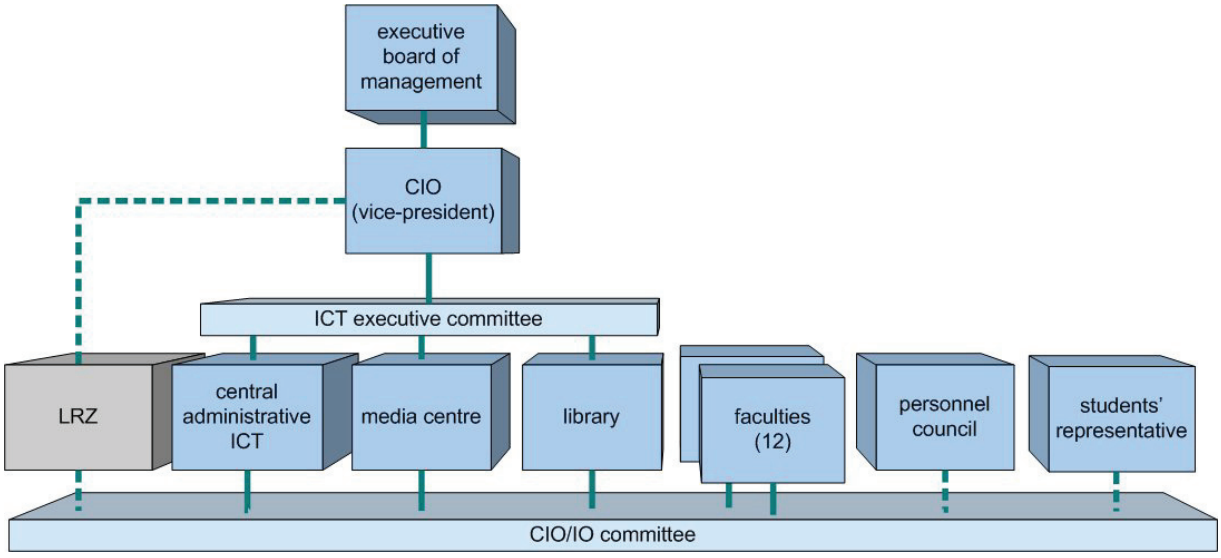

Figure 2: CIO/IO committee at TUM

The overall responsibility for the ICT of TUM is with the CIO in the rank of a vice-president. This office was created in 2001. With the help of the CIO/IO committee (see Fig. 2) the vice-president determines TUM's ICT strategy. Members of the committee are the persons responsible for ICT (Information Officers, IOs) in the different faculties, one representative of the Leibniz Supercomputing Centre and representatives of the central ICT related units (library, media centre, central administrative ICT) as well as one representative of the personnel council and a students' representative. The CIO/IO committee meets four times a year. The committee is informed regularly about the progress of the central projects and provides further requirements.

The IOs of the faculties are appointed by the dean and are responsible for the ICT within the faculties.

The CIO steers the central ICT related units in form of a matrix organisation. The CIO meets regularly with the directors of the central ICT units in the ICT executive committee.
The personnel council, the commissioner for data protection and the students' representatives are informed regularly about current and planned activities and are included directly into the work as required. Thus valuable requirements can be collected and conflicts can be avoided. The start of new central ICT projects with effects on the faculties is formally decided by the extended university directorate (EHL). The EHL assigns steering committees to accompany and control the projects.

One of the main goals of the CIO/IO committee is to define and distribute services between LRZ, central ICT-related organisational units and faculties to achieve higher quality of service, concentrate knowledge, solve organisational problems and legal issues.

6. ICT Landscape, Architectural considerations

The ICT system landscape of a university is very heterogeneous [Sch07]. In case of TUM these systems are:

- SAP HR for administration of human resources
- SAP FI, CO etc. for financial administration
- HIS SOS for student administration
- HIS POS for exam administration
- UnivIS for course administration
- ALLFA for facility management
- SISIS as library system together with a number of systems for electronic journals and interlending
- mediaTUM as digital library
- imc CLIX as eLearning platform
- MyTUM as central web portal / information broker and a large number of web information systems of the different faculties and chairs
- Computing Centre infrastructure services like email, storage, backup, compute servers, net infrastructure, firewalls etc.

The core systems for campus management and teaching (eLearning, library systems) are more or less monolithic systems with proprietary data management systems, implementing complex business processes with help of proprietary user interfaces. The systems have overlapping functionalities (e.g. calendars) and manage partly similar or redundant data (e.g. users, students, staff). The systems have only very limited technical interfaces and are far from being service oriented. Therefore, the possibilities to interconnect the different systems are limited.
A number of different approaches to generate an integrated environment for the different classes of users exist, ranging from integration of a selection of the different systems under a common web portal e.g. at the universities of Karlsruhe and Aachen, to more loosely coupled approaches mainly focused on organisational change e.g. university of Cottbus. For a good overview see [Deg07].

TUM follows an approach which starts from an analysis of the different business objects in the university and the related business processes. We define which systems are responsible for which business objects and make these systems the only source for these business objects. This is done by a mixture of technical and organisational measures.

The first step in this process of consolidation is the centralisation and standardisation of the systems used. This step has been accomplished successfully for all business applications except exam administration (see below).

The second step is the consolidation of commonly used business objects, namely:

- Master data of the members of the university
    - Students
    - Staff
    - Guests
    - Alumni
- Organisational structure

- Courses

The definition of the systems and persons responsible for input of the data and the systems and persons consuming the data must be defined and implemented. Besides, the technical implementation information and training of users is essential. By switching from paper based workflows to technical workflows special attention must be paid to quality of the data. Examples of this consolidation will be described below.

The consolidation of the master data of the members of the university is a prerequisite for (re)centralisation of commonly used ICT systems like email, eLearning, storage etc. It allows automatic provisioning and de-provisioning of users with access to the different systems and is basis for unified login or even single sign on.

7. Development Focus

Based on the considerations described in the previous section a number of technologically and organisationally closely interlocked projects were initiated [Bod05, Bor06]:

- IntegraTUM - ICT infrastructure and integration of different systems [IN07], [Bou06]
  - university-wide identity management
  - connection of the personnel and student management systems, the web-portal, the central eLearning platform as well as the library systems with the central identity management
  - projects for the reorganisation of the system administration at the faculties
  - recentralisation of email systems
  - central storage for all users
  - organisational measures
- elecTUM - eLearning infrastructure on a centrally operated platform with both technological and didactical support [Ger06]
- HIS@TUM - introduction of a uniform exam management system for TUM [HIST07]
- mediaTUM – further development of the digital library [ME07]
- Corporate Design - re-launch (content and design) of the central web site of TUM [CD07]

Technological core of the development is the central identity management system. The selection of the other projects was based on the goal of quality improvement of basic ICT services (email and central storage). On the other hand new business services (eLearning, mediaTUM, and web-portal) were implemented to increase the acceptance of central solutions within the university. The projects for the reorganisation of the system administration in the faculties serve for the test and dissemination of the new services. We aim at improving the system administration by strengthening the co-operation within the faculties. The realisation of the common exam management system finally resulted from the necessities of the Bologna Process.

All systems offer web-based self-service functions for simple but frequently used processes.

Further projects e.g. the development of the alumni administration, the introduction of a multi-functional student card or the further development of the SAP system are accompanied by the CIO in order to reach the fit in the overall architecture of TUM.

The organisational development is interlocked with the development of the aforementioned projects.

To illustrate the challenges of these projects we describe the directory service, the introduction of a standardized exam management system and the eLearning system in the following sub-chapters in more detail.

7.1. Directory Service

The identity management system serves as central (de-)provisioning and authentication system and distributes master data of university members to the systems attached. The central identity management system is a precondition for the implementation of central services.

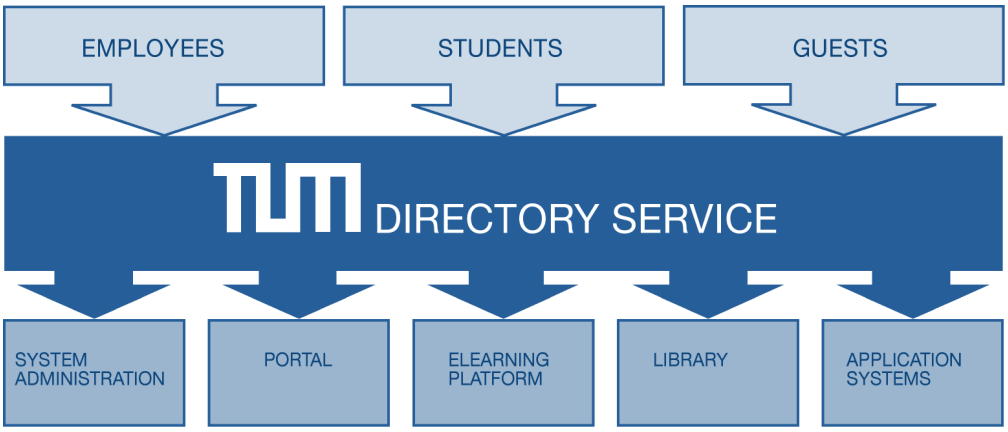

Figure 3: IntegraTUM's Directory Service

For the university-wide identity and access management an LDAP (Lightweight Directory Access Protocol) based directory service was developed. It provides a big variety of different applications and services with the user data needed. Before, each application had to store user data and login information by itself – a profile for a new user had to be created for every single application. Now a user profile of a new member of TUM will be created once centrally. After that it is provisioned to the central directory service. From there it is distributed to the systems attached to the directory. The directory service retrieves data from the human resources system, the student administration system and a guest management software (see Fig. 3).

Students get their login and initial password at the time of matriculation. Staff get their access information during the hiring process. Almost all rights on the ICT systems of TUM end automatically with end of study or end of employment respectively. Instead the member of TUM gets an alum status. Guests can be easily brought into the system. Their rights are administered based on their needs; the validity of the rights is always temporally limited. By organisational means we make sure that one person gets only one digital identity, regardless whether (s)he is member of the university as student, employee or guest.

Data protection is implemented by restrictive propagation of attributes to target systems on a need-to-know basis. All coupling of new systems must be granted by the data protection

officer. Access to the directory with the sole goal to verify passwords is granted without approval of the data protection officer. So the acceptance of the system in the student body and the personnel council is very good, at the same time a number of systems are using the authentication mechanisms offered thus leading to a further propagation of the central user login.

For example, the internal user database of the central eLearning platform (see below) is fed through a connector attached to the directory service. This way user accounts are created, modified and deleted automatically. Students and staff get a default set of user rights automatically; further rights are still subject to the internal access control methods of the platform.

The central directory service achieves a tight coupling of the connected services and systems. Better scalability, less data inconsistencies, unified login and reduced costs are further benefits of the system [Bou06].

7.2. Examination Management - HIS@TUM

Due to the Bologna Process all programs of study have to be switched from the former "Diplom" degree to the modular bachelor and master system. Until 2008/2009 more than 110 TUM study programs have to be reinvented. For this change, all courses have to be reviewed in detail and changes implemented individually due to several new rules (e.g. modules or ECTS points). The adjustments not only mean rethinking and a lot of work for each party involved. Compared to the former Diplom system the number of exams increases by one order of magnitude. Finally the number of interdisciplinary courses increases.

It is obvious, that the challenges can only be solved on basis of a harmonized legal and organizational environment and by use of a centralized exam management system. The implementation of the legal, organizational and ICT system is done in the project HIS@TUM [HIST07].

As legal basis a common examination statute for bachelor and master courses was developed. It defines sizes of modules, rules for passing of exams, ECTS points required per term etc.
From the organizational point of view a so called quality standard was approved. It defines the relation of the many organizational units dealing with exam administration among one another as well as the relation of examiners and students towards the organizational units.

At TUM a step-wise introduction of the exam management system HIS POS of the HIS GmbH [HIS07] is currently underway. In co-operation with experts from the faculty each study program has to be modeled individually in HIS POS with its examination regulations, courses, operations and users.

For the administration of the student master data TUM uses HIS SOS. In HIS POS the individual study programs are modeled, authorization for examiners and students' performance maintained. By use of the web-interface HIS QIS, which builds on HIS POS, examiners as well as students have access to the system. For the examiners this offers the possibility to enter exam data. Students can sign-up for exams and see their results. Authentication of students as well as examiners in HIS QIS is done via the central TUM identity management system.

Meanwhile about half of the bachelor and master courses is modeled and administrated in the HIS POS system. The main challenges of the project where about legal aspects and the training not only of administrators but also of students and examiners, which had to cope with a completely new system, while old processes had to be maintained for students of former Diplom courses.

7.3. eLearning - elecTUM

The eLearning project elecTUM aims at a thorough and sustainable implementation of eLearning at TUM. It includes the technical integration into the existing ICT infrastructure as well as the integration into curricula and work processes of students, faculty and staff. A seamless technical integration ensures the acceptance of this new service. [Ger06]

At TUM eLearning starts with all kinds of learning materials, e.g. scripts, slides, additional training material, digital recordings and ends with highly sophisticated WBT (web based trainings).

To convince the lecturers to present their learning material within the central eLearning platform and not scattered throughout chairs and personal homepages anymore, a good support is needed. Technical as well as didactical support is offered in form of training, faqs, regular and on-demand workshops. Furthermore, the support of elecTUM is 2nd level to the central ICT service desk.

The integration of eLearning into the ICT landscape has several aspects, like automatic provisioning of course and user data, unified user login, support and portlet integration to other web systems:

All courses are transferred automatically from the UnivIS (course administration system) into the eLearning platform to eliminate redundancy. The lecturers then have access to their individual courses and can start adding learning material and further information for the students.

Students and lecturers use their TUM login for the platform. They don't need a new account for this service. This fosters the acceptance further.

The courses a student has signed up for, are transferred from the eLearning platform onto the central web portal myTUM and shown there as a personal list.

8. Current Status

The status of the different projects in May 2007 is described briefly in the following section.

The identity management system is productive in a first version. The provisioning of all staff members and students with accounts is automated. A number of centrally hosted systems (eLearning platform, portals, vpn access, self-service access to the exam management system etc.) are using the authentication infrastructure. Further decentralised systems (e.g. faculty web servers, faculty evaluation platforms) use the authentication infrastructure for their needs. For the recentralisation of email on the systems of the LRZ a new mail system has been implemented. Grey listing improves spam and virus defence. About half of TUM's members use this system today. The recentralisation of existing decentralised email systems is under

way. The central storage system for all members of the university is in pilot test. The project for the reorganisation of the system administration prepares the integration of students' computer pools and chair computers into the identity management system. Interfaces are created in the central web portal for self-service administration processes for the different services.
The elecTUM eLearning project is productive since the winter term 2005/2006 and has now more than 10.000 users. The platform used by eLearning is the system CLIX by imc AG. It is operated by LRZ. The platform is accessible for every member of TUM. The project offers didactical support for lecturers in the form of training courses and consultation. The integration of eLearning with the exam management system and the SAP HR personnel management system (for further training of staff) is planned.

In the HIS@TUM project a common examination statute for bachelor and master courses as well as a quality standard were compiled, which give a common organisational basis for the exam administration of all courses of studies of TUM. The conversion of the different master and bachelor courses takes place gradually and is approximately half finished. The self-service functions for lecturers and students are productive.

The mediaTUM project is financed by IntegraTUM. It provides a media server for electronic books, digitised pictures and videos. The media server for electronic books is productive and contains the electronically available theses of TUM, a number of large collections of pictures and some videos.

On the occasion of a redesign of TUM's central web-site the contents as well as the responsibilities for the contents were restructured.
For the new services an appropriate support is needed. Therefore a central service desk has been started. Further details on the concept and the current realization can be found in [Kni07].

9. Chances and risks

The described projects implement TUM's ICT strategy. The projects are carried out by the existing ICT units, partially with the help of existing, partially by new staff members. It was the explicit intension no to create any new organisational unit. Thus it was possible to use the existing know-how optimally and to address the change process together. The implementation of the ICT strategy by a number of smaller projects increases the overall probability of success in comparison with a single large-scale project. On the other hand projects of central importance e.g. the identity management project require increased attention from the overall project management. The overall project management of IntegraTUM therefore consists of two persons. They also guarantee the coherence of all central ICT projects as aides to the CIO.

A large part of the infrastructure projects (identity management, recentralisation of email and central storage) are accomplished by LRZ. LRZ was expressly encouraged by TUM to compile solutions which are applicable also for other universities in Munich. LRZ is strengthened by this as a partner.

The transitional phase of the projects from the development to the productive setting takes place in parallel. Appropriate communication with the members of the university represents thereby a special challenge. On the one hand too early expectations must be avoided; on the

other hand the development of further isolated solutions has to be prevented with regard to the completion of the central services.

We are convinced that the role of the CIO with a direct representation in the university's directorate is a good choice. The coupling of the CIO with the ICT units of TUM via a matrix organisation has proven to work. A formal determination of the role of the IOs is in progress. As soon as the projects have merged into a regular operation, the selected organisational form should be re-examined for suitability.

10. Summary

Leitmotif of TUM's ICT strategy is the Digital University. The ICT strategy follows TUM's overall strategy. For the implementation of the strategy a number of organisational adjustments have begun and a multiplicity of interrelated projects were started. All projects have in common that they both standardise and recentralise existing services or that they provide new centralised services. The role of the LRZ as the computing centre for the Munich universities is strengthened. The present conditions of the projects are very promising.

11. Acknowledgments

The projects described could not have been accomplished to the planned extent without the support of third parties.

The IntegraTUM project is realised under partial funding by the German Research Foundation (DFG) from 2004 to 2009. Funds in the same amount were made available in the context of TUM's InnovaTUM renewal program. Furthermore the permanent staffs of TUM and LRZ make substantial contributions to the projects.

The elecTUM project is promoted by the German Ministry of Research (BMBF) within the framework of the program "eLearning services for science", and is supplemented by permanent staff members.

The HIS@TUM project is financed by TUM's own resources.

Above all we would like to thank all members of TUM and of LRZ, who participate with advice, work and creativity in the projects.

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