The United Nations
University

UNU/IIST
International Institute for
Software Technology

$$\Gamma \vdash x : A$$

$$\frac{\Gamma, x : A \vdash t : B}{\Gamma \vdash \lambda x : A.t \quad : \quad A}$$

$$\frac{\Gamma \vdash t : A \Rightarrow B \qquad \Gamma \vdash}{\Gamma \vdash t(u) : B}$$

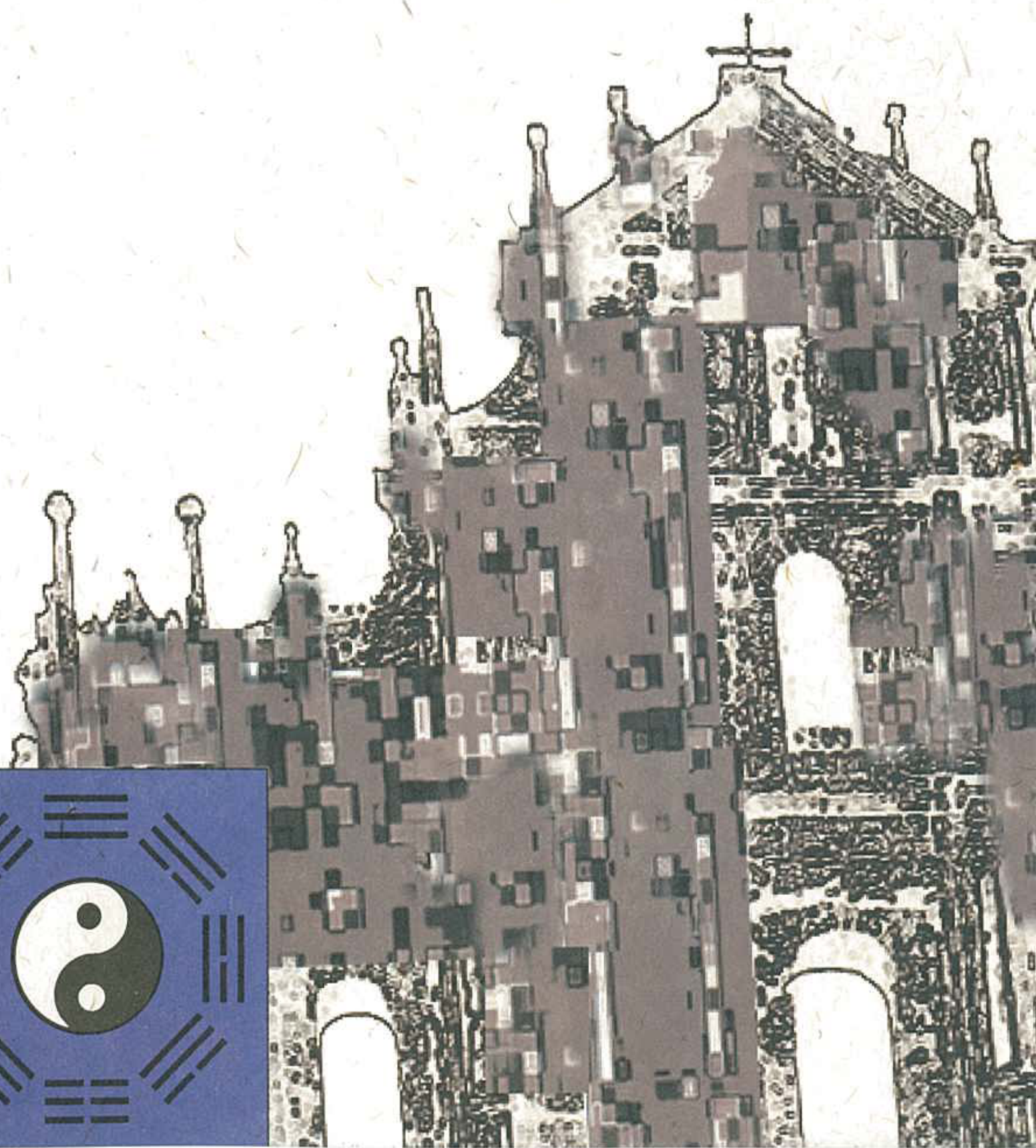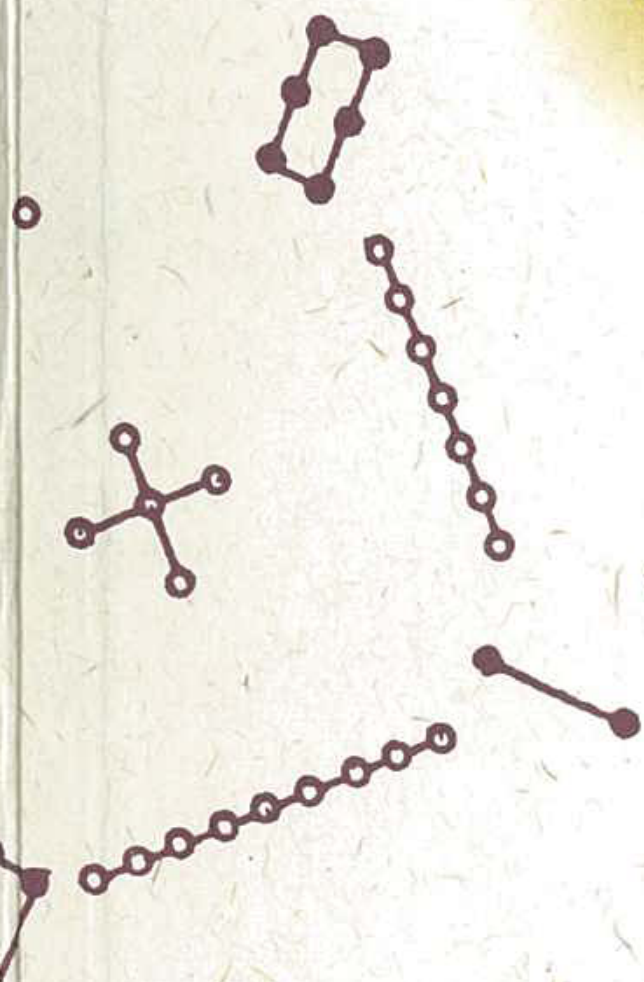$$\frac{\Gamma \vdash t : A}{\Gamma \vdash \Lambda p.t \quad : \quad \forall p.A}$$

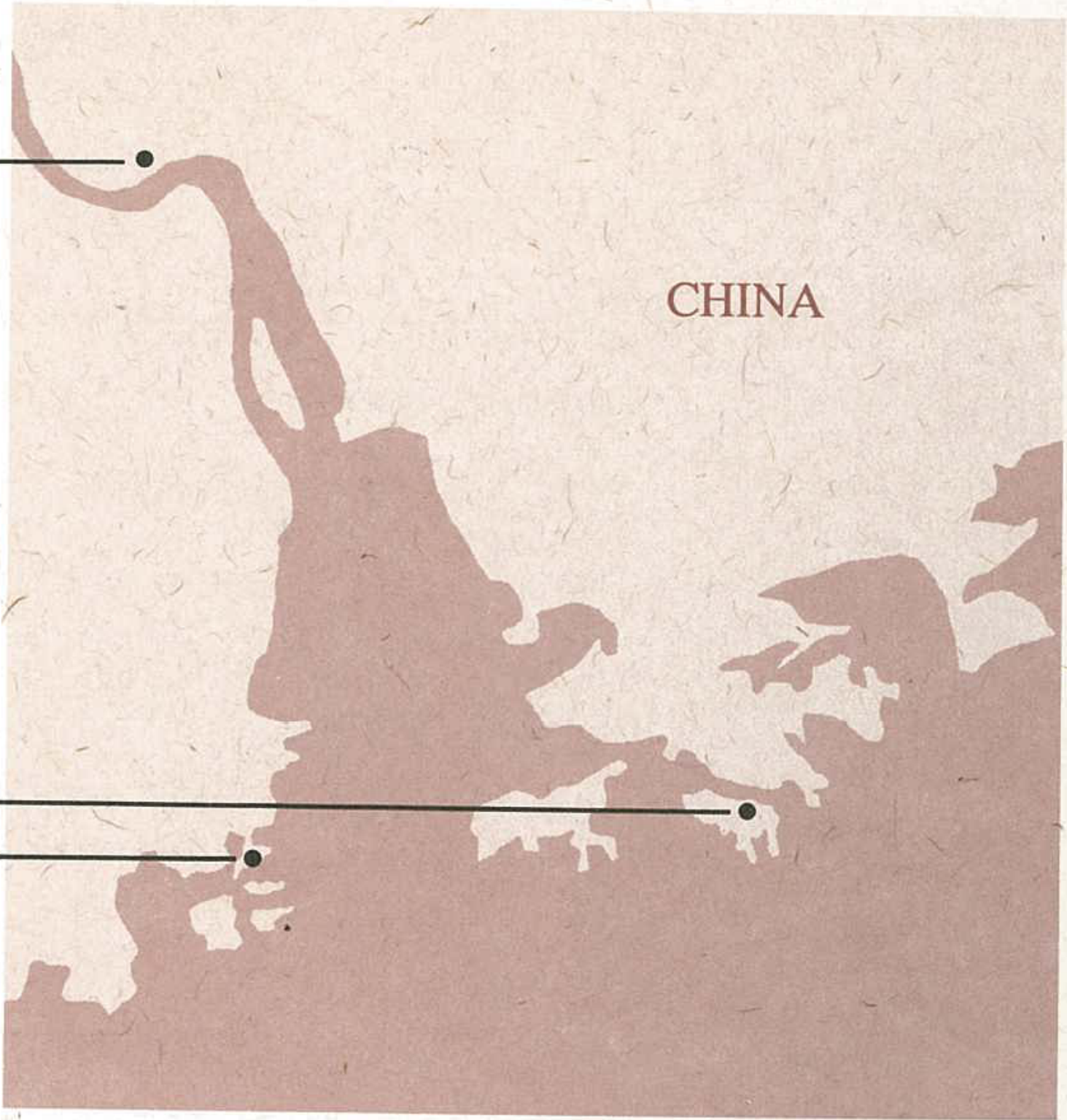$$\frac{\Gamma \vdash t : \forall p.A}{\Gamma \vdash t\{B\} : A[B/p]}$$

GUANGZHOU ●————

CHINA

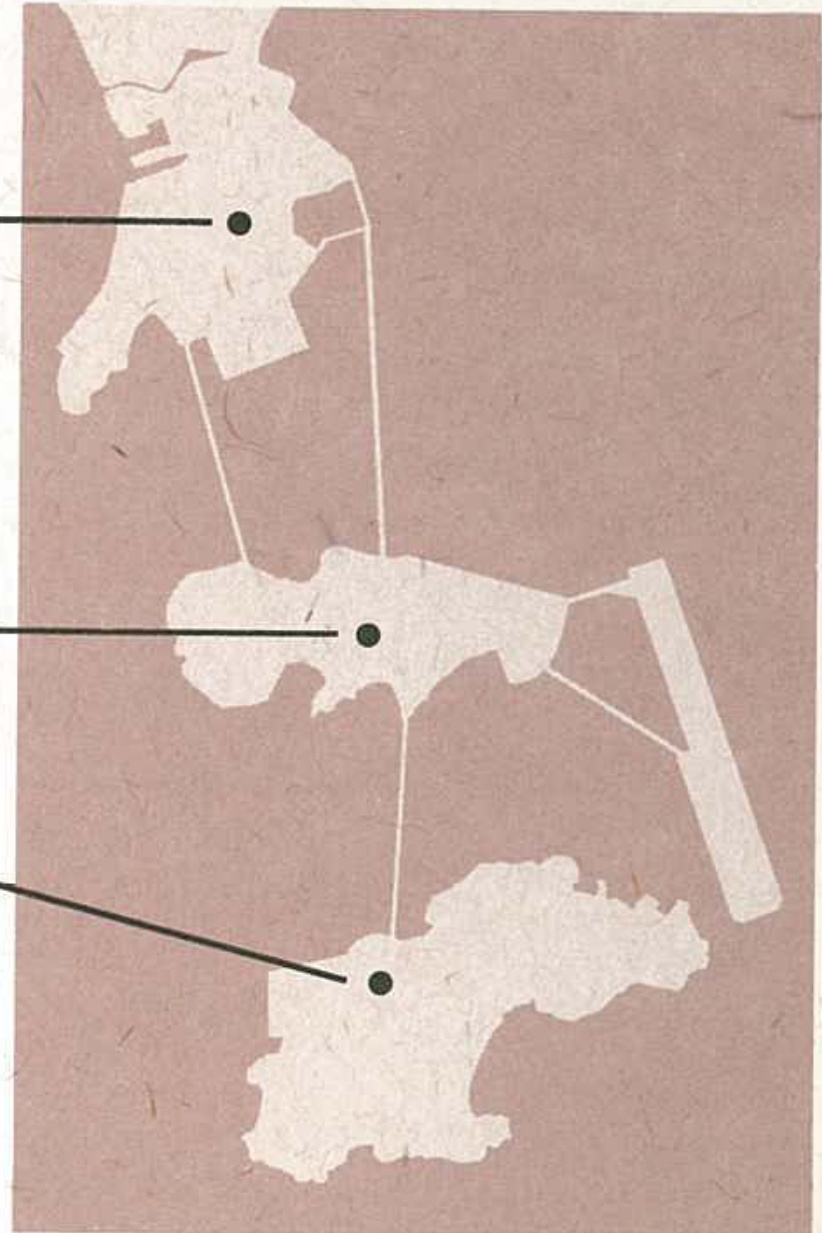HONG KONG ●————
MACAU ●————

MACAU ●————

TAIPA ●————

COLOANE ●————

*Cover shows the eight trigrams:
BA GUA — an early Chinese
coding of 0-7 with an inserted
Yin - Yang symbol. The 18th
century mathematician Leibniz
is said to have derived his
invention and study of the
binary system on the Ba Gua.*

The United Nations University

UNU/IIST
International Institute for
Software Technology

MESSAGE FROM THE DIRECTOR

UNU/IIST is now well into its second year. Programmatic activities, institutional build-up and contact-making have characterized the first year. The institute is now well housed, occupying some 600 square meters of the entire 18th floor of an office building on the waterfront, centrally located in downtown Macau. A splendid view, from our offices, over the Pearl River Delta, South China Sea, the Territory of Macau, nearby Hong Kong islands and neighbouring Zhuhai Special Economic Zone of the Guangdong Province of the People's Republic of China combine with library and seminar room facilities to provide an excellent working environment. We are already engaged in exciting programmatic activities and are ready and eager to expand. South East Asia offers great challenges, but the mandate of UNU/IIST goes beyond this region. UNU/IIST will increasingly spread its attention to a widening circle of developing countries.
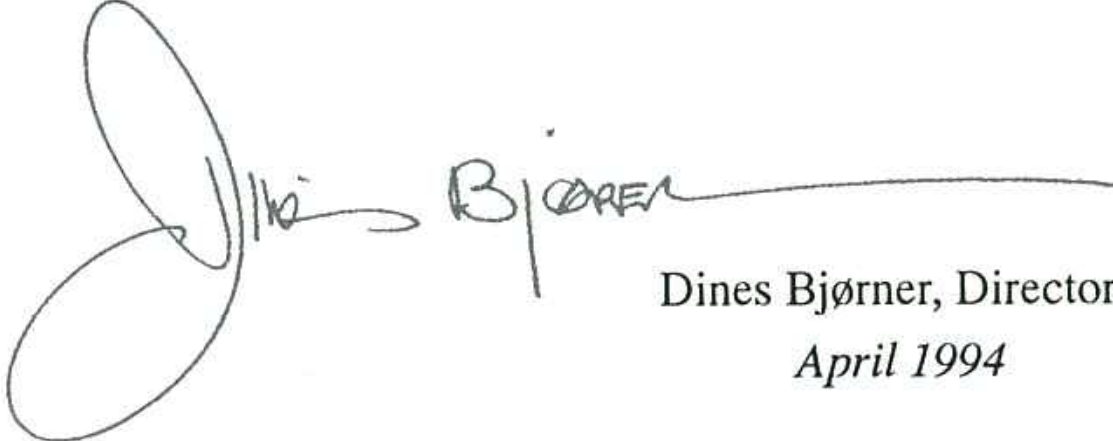
In my time as Director, UNU/IIST will be devoted to propagating the fascinating theories, technologies and methodologies that now characterize the forefront of our field and which emphasize how to develop reliable software over a wide spectrum of applications important to developing countries. We know of no boundaries that will prevent us from trying to ensure awareness of the most relevant technology today available for the use, for trustworthy development and proper understanding of high integrity software. UNU/IIST must ensure that capable industries, universities and research institutes of developing countries can have access to the best intellectual results: there can be no embargo here!

Our main task is 'technology transfer'. Our approach is, we sincerely believe, not only unique, but also the only viable one known.

We transfer technology "up front": (i) we work closely with the targets of the transfer, both in industries, universities and research institutes, (ii) not after the technology has already been developed, but already as from the very earliest phases of development, (iii) while training leading staff of the targets, we together research and develop advanced applications, and (iv) we do it across borders, not only north-south, but also south-south.

These are the characteristics needed for evolving software industries, university departments and academy research institutes in developing countries to become successful on the international scene.

Software technology is inter-disciplinary and our programmatic activities reflect the application of computers across a wide terrain. This Brochure will indicate a spectrum. It is issued with the hope that you will find it instructive, and that you will be able to connect up to UNU/IIST: propose joint activities, provide funding, or assist in other ways.

Dines Bjørner, Director
April 1994

The UNU/IIST population, March 1994

CONTENTS

1.1 MOTIVATION

UNU/IIST is fundamentally concerned with the software technology needs of developing countries. It is the first international science institute devoted to this subject. The Institute has joined the family of *Research & Training Centres* of the *United Nations University* (UNU) at a time when, although the growth of computer usage in the developing countries is quite high, most of them urgently need the establishment or expansion of both basic and advanced training, development and research facilities. Thus there is at once a lack of available software professionals for industrial growth and a chronic shortage of educators and trainers of the professionals of the future.

Moreover, most developing countries have few software companies and little experience in industrial software development. Local software development is essential in developing countries, not only to establish and strengthen the local industry, but also to provide software in local languages and with cultural features adapted to the specific needs and conditions of each country.

Although the knowledge and competence gaps between the industrialized and developing countries may be substantial, UNU/IIST can still help specialists in developing countries reach state-of-the-art levels in software technology.

UNU/IIST represents a *stable body* that can carry out the plans outlined in this booklet, and which can *persist* in doing so. Since the identified need must be alleviated through international co-operation, and with a significant academic component, UNU/IIST is the proper institution for doing so.

1.2 FOUNDATION

UNU/IIST is a Research and Training Centre (RTC) of the UNU. It formally came into being on March 12th 1991, with the signing in Macau of agreements between the UNU, the Governor of Macau, and the Governments of Portugal and the People's Republic of China. It is being financed initially, over a 5 year period 1991-1996, by a fund of US $ 30 Million contributed to the UNU Endowment Fund in respect of UNU/IIST.

The Governor of Macau has further provided generous support in the form of special operating contributions for 1991-1993, as well as temporary premises, furnitures and fixtures. A fine Patrician Villa is being offered by the Governor for consideration as the future permanent premises of UNU/IIST.*

UNU/IIST commenced operations on 2. July 1992.

* The rear cover of this document shows Architect A.Bruno Soares' proposed Feb.94 design.

1.3 AIMS AND OBJECTIVES

UNU/IIST will assist developing countries in meeting needs and in strengthening capabilities for the purposes of their indigenous capabilities in three activity areas:

- development of their own and exportable software,
- university education curriculum development, and
- participation in international research.

Through the above, UNU/IIST expects to propagate use of as sophisticated a variety of as advanced software as reasonable.

UNU/IIST will help to bridge gaps between theory and practice, university and industry, consumer and producer and industrialized countries and developing countries.

A UNU/IIST 'Credo' can be enunciated:

1. UNU/IIST is a *cradle* for educating young university computing scientists and industry programmers and software engineers above post-graduate level.

2. UNU/IIST offers a *showroom* for demonstrating paradigmatic approaches to application modelling, requirements engineering, programming, software engineering and software technology management techniques and tools.

3. UNU/IIST serves as a *bridge* for enhancing co-operation between industrialized and developing countries in the area of software technology.

4. And UNU/IIST constitutes a *channel* for bringing to international attention achievements of developing countries.

UNU/IIST interfaces with a number of UN System agencies: UNDP, UNEP, UNESCO, UNIDO, WHO, as well as to international financial institutions such as: The World Bank (IBRD), ADB, IADB, EBRD etc. UNU/IIST aims with great specificity at developing and disseminating *enabling technologies* and *empowering and building-up capacities*. Thus UNU/IIST is in many cases the most relevant instrument available for ensuring the best information technology content of many international reconstruction and development programmes.

UNU/IIST, matching the three activity areas mentioned previously, directly targets the following audiences and clients:

- industry software developers and the software industry;
- university lecturers and computer science departments; and
- scientists and research institutes.

Indirectly, UNU/IIST also targets the United Nations System and international aid agencies and development & reconstruction banks – aiming to serve these organizations as a consultant on matters of information technology.

Software developers: The software industry is rapidly accelerating the sophistication of its production techniques and tools. To become providers of software, product qualities are expected which are only attainable through the use of state-of-the-art development techniques. UNU/IIST will offer leading-edge developers, as well as university lecturers – from developing countries – education courses in software development techniques, and will offer them active participation in 9-15 month feasibility, demonstrator and prototype product development and technology transfer projects.

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A Traditional Mongol Script Language Word Processor – illustrating a need of developing countries for national script computer-human interfaces.

Technology management: Large scale software users, and the management of software houses are in need of applying the latest techniques related to technology management. Users need to know techniques for tendering and procuring software, and for managing computing facilities. Developers need know techniques for bidding for software development contracts, and for managing projects and products. UNU/IIST intends to offer such managers awareness courses in applicable techniques.

University lecturers: With the advent of modern techniques for software development, existing computation science and engineering courses are becoming

rapidly obsolete. Universities in developing countries also may need to revise their curricula. Through the software development education courses mentioned above, and through special two-three week training workshops, UNU/IIST will offer the contents of a modern computing systems curriculum, and conduct in-depth workshops analysing such curricula.

Computing scientists: Research communities in industrialized countries are becoming increasingly internationalized. They generally have easy access to electronic networks, participate in internationally sponsored joint research projects, and have reasonable funds for journals, books, and equipment, incl. software tools. Its researchers travel regularly, often two-three times annually, facilitating their participation in meetings of various kinds. UNU/IIST will help towards globalising the research of developing country scientists through joint research efforts and by conducting international workshops and seminars.

Software users: National and local government planners and administrators are faced with increased demands for the computer supported gathering and evaluation of socio-economic data. Local, national and regional professionals in for example public health, agriculture, fisheries and transport are expected to apply computers in forecasting, planning and decision making. Small business and industry management must increasingly apply computers in day-to-day operations: budgetting, accounting, forecasting, inventory control, order-processing, invoicing, product planning, monitoring and control, machining, marketing and sales. UNU/IIST intends to offer such users training courses in software installation, operation, data preparation and output interpretation through its Network.

A diagram showing an example Labanotation – a formal notation for body movement, here used to illustrate choreography, in particular Bournonville: Flower Festival of Genzano – an example of a real-time specification requiring artistic interpretation.

9
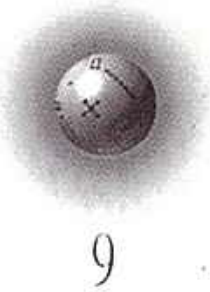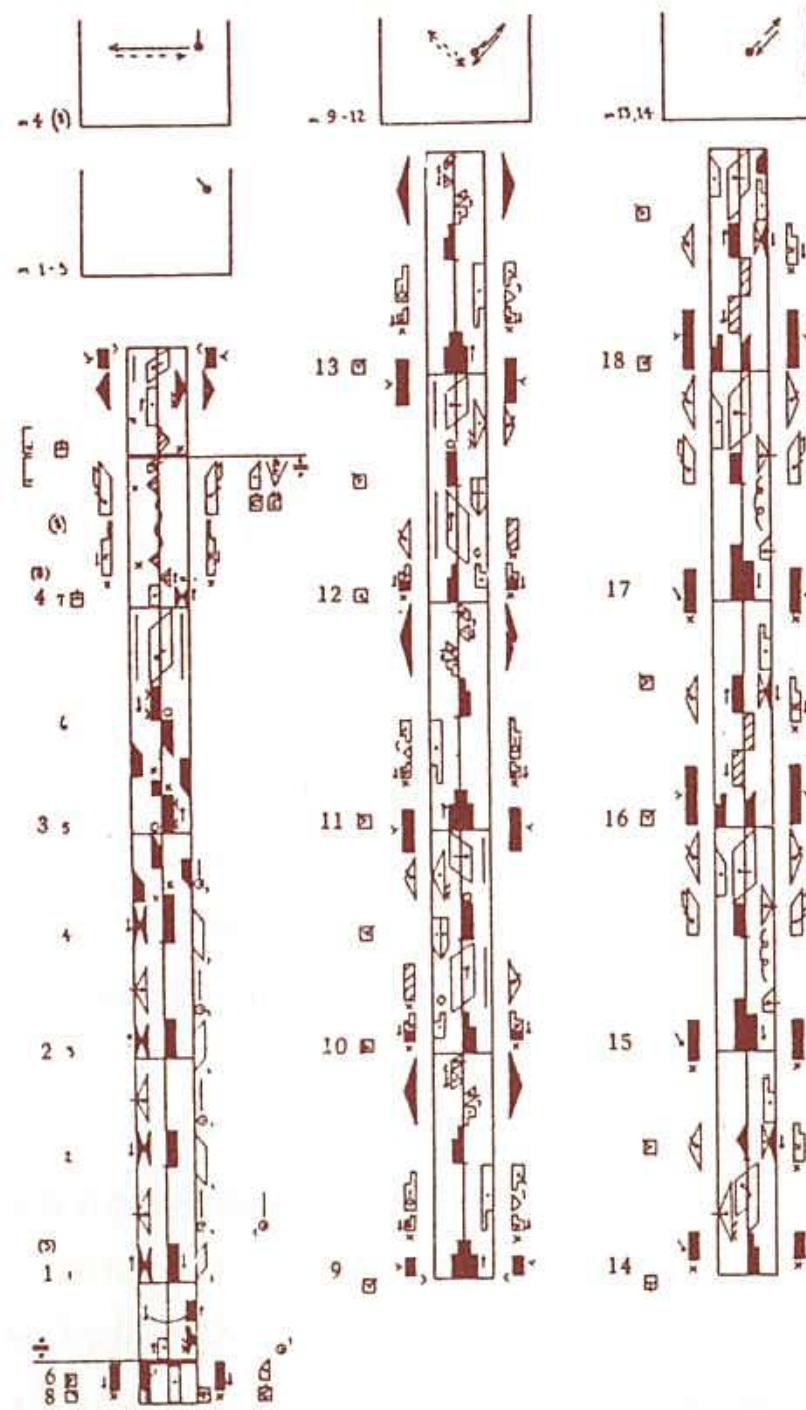
PROGRAMMATIC ACTIVITIES

UNU/IIST Programme Activities centre around projects, training, research, dissemination, events, and consultancy. The level of activities will ultimately depend on available funding.

3.1 ADVANCED DEVELOPMENT PROJECTS

UNU/IIST engages in feasibility, exploratory, demonstrator and technology transfer projects. All projects are jointly undertaken with industry and other institutions in developing countries. The projects develop actual software using advanced techniques. They are decomposed into phases lasting from nine to 15 months, and they all involve 'Master Class' training of usually four to six fellows per phase at UNU/IIST in Macau. UNU/IIST staff, visiting experts and fellows will together conduct these Macau-based projects.

Feasibility & Exploratory projects formally, but experimentally develop small, but difficult subsets of innovative software applications – and may lead to follow-on demonstrator projects. These projects may be prompted by, or lead to research done at UNU/IIST or within the UNU/IIST *Organic Network*. *Demonstrator projects rigorously* apply scalable, state-of-the-art techniques to applications that can serve as the basis for software development education courses – and may lead to follow-on technology transfer projects. *Technology transfer projects* systematically develop core, prototype parts of planned products and lead to detailed plans and technical directions which are then transferred to some developing country group for concluding, full-scale development.

An important component in most projects is the establishment of Enterprise Models . Such models are indispensable in disaster relief and recovery, in industrial development in developing countries in the context of the environment, in securing balanced introduction of computing for university, for health care systems and for railway system operation and management, and in creating new (initially small) industries. "Blindly" – as it is – developing or procuring software without such enterprise models leads, it is being witnessed (again and again), to failed business opportunities, respectively to costly operations and significant user frustrations.

The developed software may apply to *operational* systems such as railway monitoring and control, river monitoring and flood control or cargo and customs clearance, via *analytic* systems such as traffic or crop fertilization planning, disease monitoring or disaster management, to *conceptual* systems

such as expert or knowledge-based systems for decision support, university administration and management information systems, or health care systems.

A diagram showing the merge/ fan-out of railway tracks – illustrating a need for safety critical, computerized control of embedded, real-time railway systems. The UNU/IIST cooperates with the Computer Center of the PRC Ministry of Railways on the development of critical software for the dispatch and monitoring of trains along the busiest 600 km. sector of the Beijing-Guangzhou line: Zhengzhou-Wuhan.
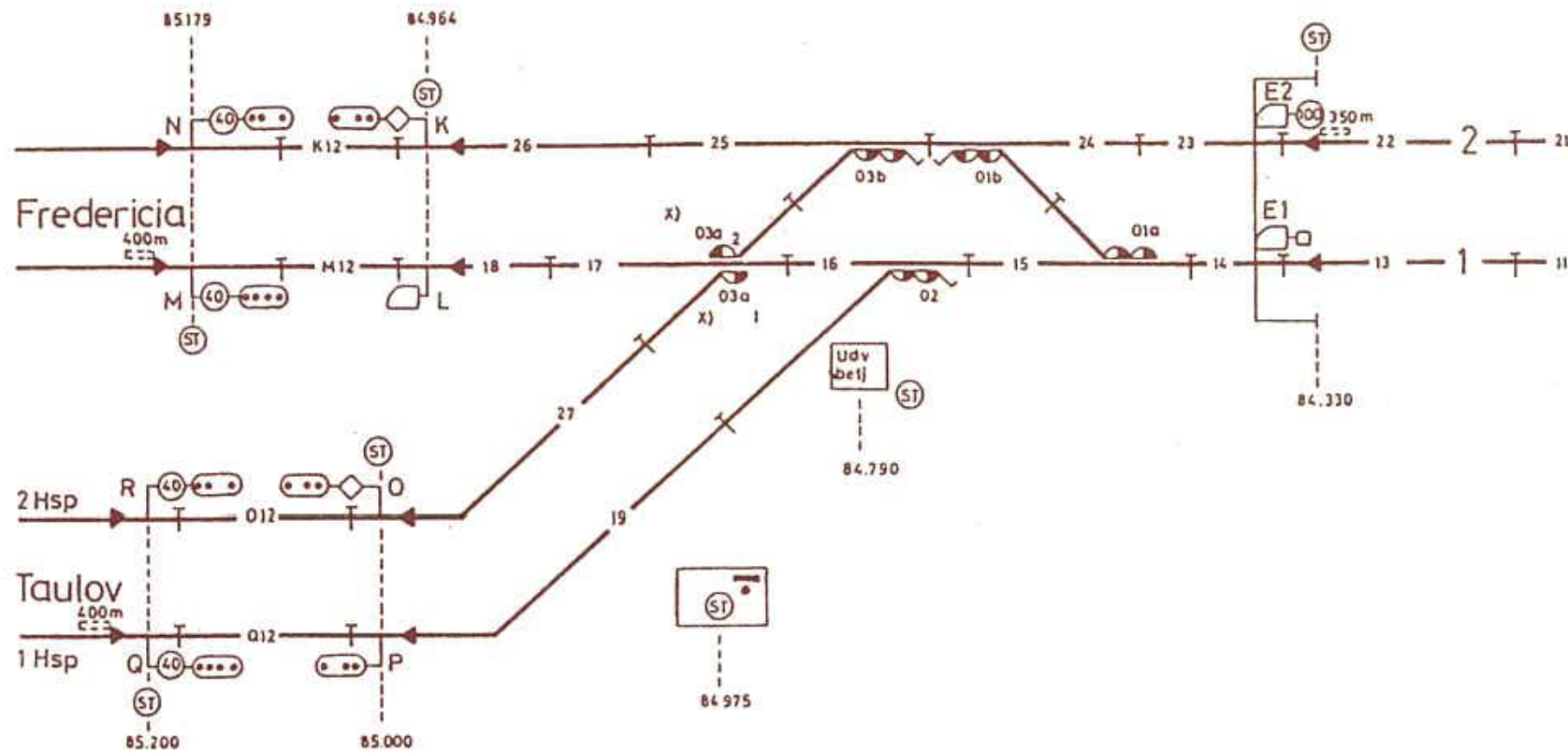
UNU/IIST expects to assist in the creation of local software industries.

3.2   TRAINING WORKSHOPS

UNU/IIST offers training to fellows participating in carefully supervised projects and through training workshops. UNU/IIST conducts four kinds of training workshops for participants from developing countries:

1. Short *instruction* courses teach software users and computer center operators to install and operate large-scale software systems, and to prepare data for and evaluate results of their computations.

2. Short *awareness* courses expose managers to the intricacies of software technology management – how to procure software, put out tender or bid for the development of software, to evaluate, negotiate and contract software, and to manage software development projects, software products and computing facilities. Common aspects include quality assurance, risk analysis , resource estimation, planning, allocation and scheduling, process modelling and simulation.

3. Longer *education* courses teach software developers and university lecturers to develop application-specific requirements, abstract and concrete program-

ming, and the engineering of large-scale software systems: fit for use and purpose, correct, fault tolerant and safety critical, efficient, maintainable and portable.

4. *Research* courses cover current research topics related to the software development facets otherwise covered in education courses.

3.3   RESEARCH

Leading information technology countries and regions of the industrialized world have long been and are still engaged in co-ordinated multi-billion dollar information technology research and precompetitive projects involving sizable software technology components. Many years of research have brought these countries up to a very sophisticated level of software technology techniques which increasingly are being applied industrially under controlled supervision.

UNU/IIST will bring results of this research to scientists in developing countries through frequent, typically off-shore research seminars. UNU/IIST will itself conduct research – with this research being conducted by UNU/IIST in-house staff, visiting experts and fellows. And UNU/IIST will co-sponsor joint, off-shore research collaboration, including joint research projects.

Young *research trainees* may thus consider their time at UNU/IIST as an internship part of their Ph.D. studies.

3.4   DISSEMINATION

To reach growing software technology segments of the developing world, UNU/IIST plans to issue, at regular intervals, *a Software Technology* Monitor to managers, programmers, software engineers, lecturers and researchers of developing countries. The monitor will track international public domain as well as commercial software products, and technological and scientific events and developments both in the industrialized and in the developing countries. The *Software Technology Monitor* will also bibliograph and, in some cases, review seminal books and track relevant journal articles and reports. Finally, the Monitor will provide survey, technical and research articles on software technology issues.

UNU/IIST also plans to publish case studies which record actual developments of advanced, reasonably large scale, application-specific software.

LIBRARY

The UNU/IIST *Library* is an important facet of UNU/IIST: reflecting a crucial "culture formation" component, and is intended also to establish trend-setting publication display and availability standards. Currently the *Library* features more than 150 international technical/scientific journals in software technology, computing and computer science, and related mathematics. Through the kind help of more than 190 leading computer science departments and public and private research institutes worldwide, the *Library* also features their reports.

Organic Network Members will regularly receive up-to-date information of selected journal contents and reports – from which they can judiciously order copies.

DATA CENTRE

The UNU/IIST *Data Centre* currently features Sun Microsystems work-stations. It is hoped that, through generous donations, it will further feature clusters of advanced work stations of other leading manufacturers. The Data Centre software will eventually, in addition to the present *RAISE Tool Set* also feature those of *B, Esterel, Estelle, Larch, Lotos, OBJ, VDM, Z* and others.

It is planned that the *Data Centre* will become a hub in a *Public Domain, Free Software and Journal* distribution network.

3.5   EVENTS

In addition to projects, training workshops, research, consultancy, and physical and electronic document dissemination, UNU/IIST arranges and co-sponsors panels, task forces, workshops and symposia. Task forces and workshops explore such issues as university curricula, professional accreditation, and software product and process standards. Task forces start out by identifying issues worthy of study at panel events; they work in a decentralized manner over extended periods; they may conduct workshops at regularly intervals; and they

present their findings at final panel events. These events involve scientists, lecturers, technologists and policy planners, from the developing world together with UNU/IIST staff and visiting experts. Additionally, scientific and technical workshops – aimed at leading edge scientists and developers from developing countries – explore new research directions and software development techniques.

$$
\begin{array}{lll}
1.0 & k{:}KIN & = L_i \overset{m}{\to}(L_{i+1}\overset{m}{\to}(L_{i-1}\overset{m}{\to}PaO')) \\
2.0 & L_i & = L \\
3.0 & L_{i-1},L_{i+1} & = [L] \\
4.0 & \pi'{:}PaO' & = \underline{s\text{-}}\pi{:}PaO\times\underline{s\text{-}}typ{:}RoP \\
5.0 & \pi{:}PaO & = \underline{s\text{-}}lnk{:}(\underline{s\text{-}}len{:}REAL\times\underline{s\text{-}}twi{:}ANG) \\
6.0 & & \times\ \underline{s\text{-}}jnt{:}(\underline{s\text{-}}off{:}REAL\times\underline{s\text{-}}ang{:}ANG) \\
7.0 & rop{:}RoP & = REV|PRI \\
8.0 & REV & :: \underline{s\text{-}}lo{:}ANG\times\underline{s\text{-}}hi{:}ANG\times\underline{s\text{-}}init{:}ANG \\
9.0 & PRI & :: \underline{s\text{-}}lo{:}REAL\times\underline{s\text{-}}hi{:}REAL\times\underline{s\text{-}}init{:}REAL
\end{array}
$$

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3.6   CONSULTANCY

The UN System as well as governmental and non-governmental agencies today typically employ industrialized country consultants in obtaining in-depth studies of policy, usage, industry and technical issues of software technology. UNU/IIST, with its experienced staff of software technologists, including visiting experts, offers to perform such studies – thereby bringing them "closer to home" while at the same time training a new generation of developing country graduates to perform such work in the future.

The main purpose of the UNU/IIST fellowship programme is intellectual and technological enhancement. UNU/IIST will focus on the best and the brightest, seeking out new talent in young people.

UNU/IIST offers three kinds of fellowships: nine to 15 month project fellowships, from two to four week to three month course fellowships and six to nine month research stipend fellowships. Fellows come from developing countries to work with UNU/IIST scientific and technical staff and with visiting experts. Fellows return to their country of origin and are then committed to the transfer of their experience to home country affairs: software development, university teaching and research. UNU/IIST monitors the overall effectiveness of this transfer and prioritizes its co-operation accordingly.

Correctness of Software may be elusive, but one can get closer and closer to better fulfilling user's expectations.
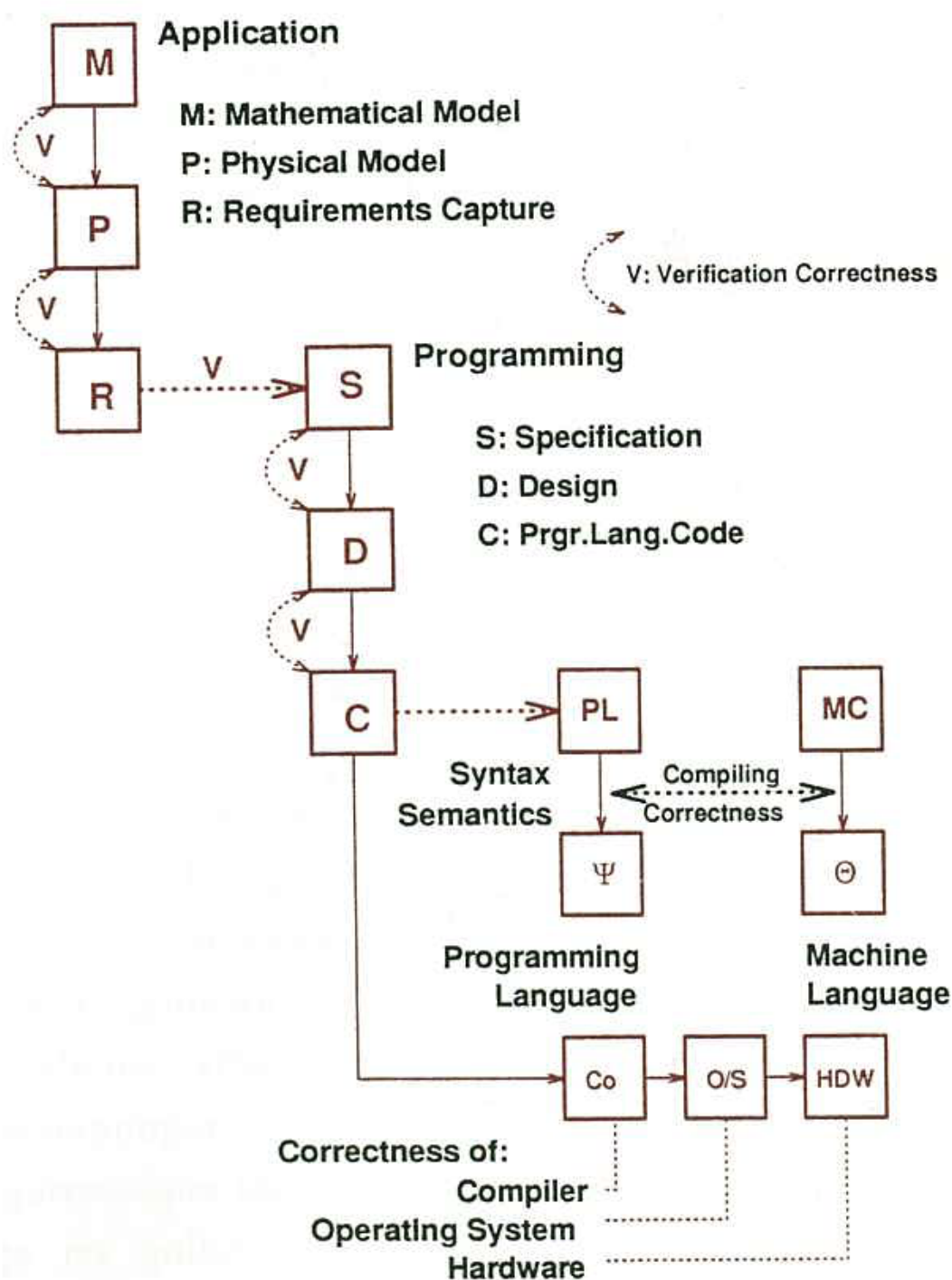
Young students are invited to spend part of their studies at UNU/IIST in the form of Ph.D. internships, for example, in the form of repeated three month visits. UNU/IIST is not itself a degree awarding institute, but endeavours to profile its research so as to become an internationally recognized center. As such, UNU/IIST will also be open to developing country post-doctoral research fellows and visiting experts.

Application

M: Mathematical Model
P: Physical Model
R: Requirements Capture

V: Verification Correctness

Programming

S: Specification
D: Design
C: Prgr.Lang.Code

Syntax Semantics

Compiling Correctness

Programming Language

Machine Language

Correctness of:
Compiler
Operating System
Hardware

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To develop software involves several disciplines: application domain modelling, requirements capture, programming, software engineering, management and computation science. Although UNU/IIST is also engaged in other, non-developmental issues, the above disciplines will be a major focus.

UNU/IIST is dedicated to the professionalization of software development.

A professional is a developer, a resident computation scientist, or a manager who is scientifically and technically interested in these fields, who knows whether a product can be developed in a trustworthy manner, who will develop software in such a manner, performing as a natural part of development calculations which reveal properties of application domain models, abstract functional and behavioral specifications, and of designs – long before costly implementation has taken place, who continuously knows whether she or he is up-to-date with the forefront of the field and is able to stay abreast through their own work, and is a person who is interested in further developing the science and techniques of these fields themselves.

As is well established in other branches of engineering, the use of mathematical modelling and reasoning about contemplated designs will be at the center of any of the development activities that UNU/IIST propagates.

5.1   APPLICATION DOMAIN MODELLING

In order to secure that the customer, the user, gets software that is fit for its intended purpose, a careful study must be made of the domain in which the software is to serve. Application domain modelling involves the mathematical expression of properties and models of concepts and facilities of the user domain, and of functional and behavioral characteristics – together forming the conceptual model. Additionally, physical models involve formalizing interfaces between components implementing the conceptual model, as well as safety criticality, dependability, performance and human-computer-interface facets. Finally, simulation models may allow experimental model executions before final requirements are captured – and in preparation for the programming and engineering of the software. Application domain modelling may, depending on application characteristics, also, or instead, involve establishing knowledge-based models that allow system reasoning during execution.

$$\nabla \times \overline{E} = -\frac{\partial \overline{B}}{\partial t}$$
$$\nabla \times \overline{H} = \overline{J} + \frac{\partial \overline{D}}{\partial t}$$
$$\nabla \bullet \overline{B} = 0$$
$$\nabla \bullet \overline{D} = \rho$$
$$\nabla \bullet \overline{J} = -\frac{\partial \rho}{\partial t}$$

5.2   PROGRAMMING

In order to secure efficiency and correctness of implementations, the latter with respect to requirements, programming now employs such precise, logical techniques that allow objective validation and the controlled, carefully motivated design decision introduction of efficiency. Typically, programming thus includes abstract functional and behavioral specifications, their stepwise design refinement into efficient implementation, followed eventually by the coding in some executable programming language. Proofs of properties of individual stages as well as correctness of stage refinements intersperse this somewhat simplified process picture.

UNU/IIST will, in its projects and education courses, propagate programming techniques of the kind represented by the *Larch, Lotos, RAISE, The Refinement Calculus, VDM* and *Z* methods, will feature proof assistant and theorem proving systems of the kind represented by *Boyer-Moore, HOL, PVS* and *RAISE* tools, and will otherwise rely on programming languages of the kind represented by *Modula-3, occam, Prolog* and *Standard ML*.

A MODULA 3 PROGRAM*

```

                        VAR m := NEW(MUTEX);
                     VAR head := List;
                  VAR nonEmpty := NEW(Thread.Condition);

                                    |
PROCEDURE Consume(): List = | PROCEDURE Produce(newElem:List) =
 VAR topElem : List; | BEGIN
 BEGIN | LOCK m DO
   LOCK m DO | newElem.next := head;
     WHILE head = NIL DO | head := newElem;
       Thread.Wait(m,nonEmpty) | Thread.Signal(nonEmpty);
     END | END
     topElem := head; | END Produce
     head := head.next |
   END; |
   RETURN topElem |
 END Consume |
                                    |
---------------------------------- |-------------------------------
```

## 5.3    SOFTWARE ENGINEERING

In order to scale up the formal programming of large systems, and, at the same time, ensure conformable, maintainable and portable software systems, software engineering employs such subsidiary techniques as conformance testing, version control and configuration management, change request identification, monitoring and control, test case generation and validation, requirements and design decision tracking, and hypermedia supported documentation.

*D.Harel's Statecharts help Specify Reactive, Real-time Safety-Critical Hybrid Systems, i.e. Computing systems that Interface to other Technology.*
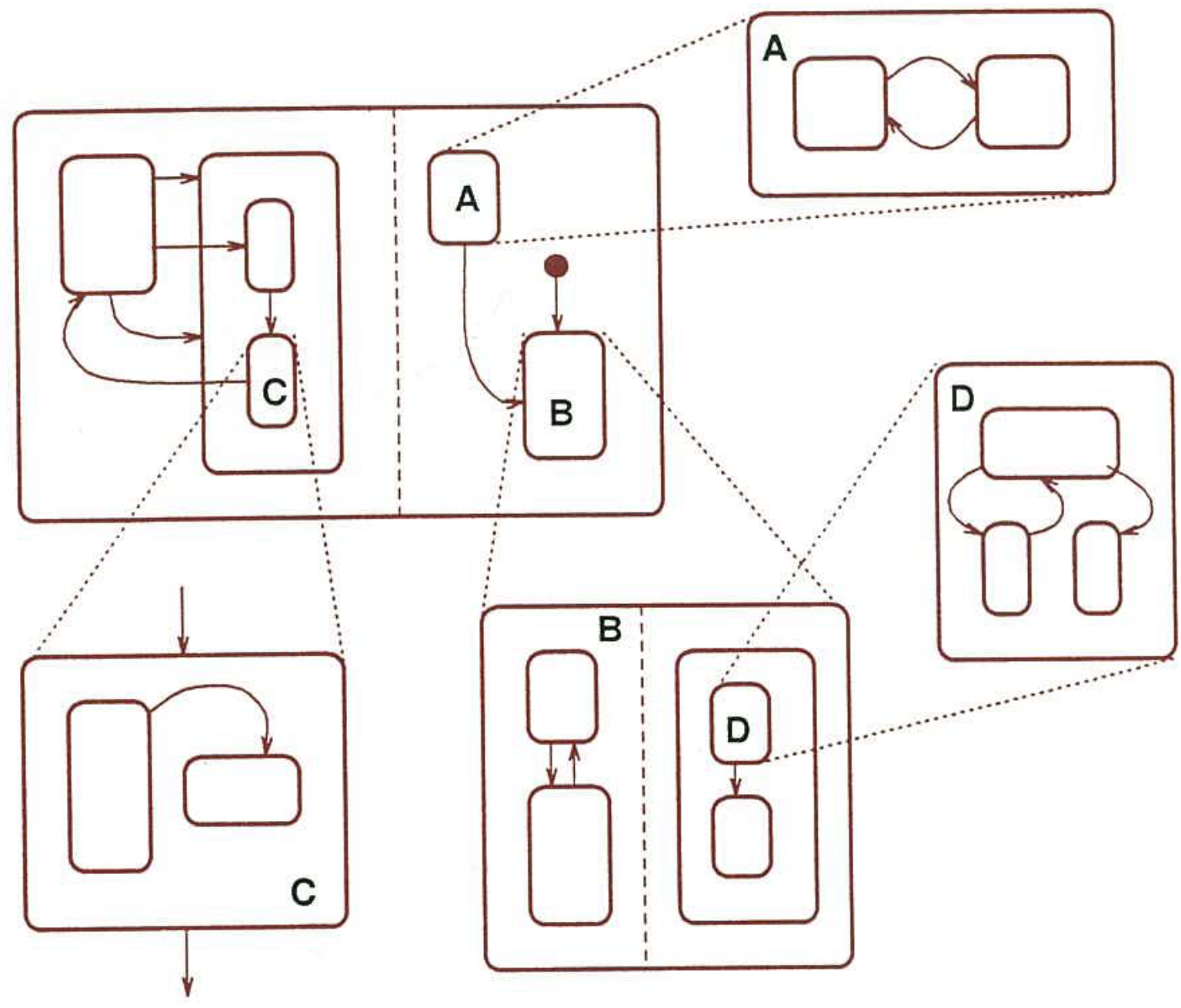
*Jean-Yves Girard's System F explains fundamental notions of λ-Calculus and Type Theory.*

$$\Gamma \vdash x : A$$

$$\frac{\Gamma, x : A \vdash t : B}{\Gamma \vdash \lambda x : A.t \quad : \quad A \Rightarrow B}$$

$$\frac{\Gamma \vdash t : A \Rightarrow B \qquad \Gamma \vdash u : A}{\Gamma \vdash t(u) : B}$$

$$\frac{\Gamma \vdash t : A}{\Gamma \vdash \Lambda p.t \quad : \quad \forall p.A}$$

$$\frac{\Gamma \vdash t : \forall p.A}{\Gamma \vdash t\{B\} : A[B/p]}$$

UNU/IIST will feature, in its projects and its education courses, Computer Aided Software Development Environments that will assist the software engineer in carrying out the above tasks.

## 5.4  COMPUTATION SCIENCE

Software developments usually entail new application domains, new functions and behaviors, and new software designs – for which state-of-the-art development techniques incl. Design Calculi only partially apply. A resident computation scientist is hence a person who can check the case-by-case validity of applied techniques, and, in cases, provide justification for the use of novel techniques.

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$$Req \triangleq \Box(SafetyReq \land FunctReq)$$
$$SafetyReq \triangleq \lceil door = i \rceil \Rightarrow \lceil floor = i \rceil$$
$$FunctReq \triangleq F1 \land F2 \land F3$$
$$F1 \triangleq \lceil i \in send \rceil; true \Rightarrow \ell \le t_s \lor (\ell \le t_s; \lceil door = i \rceil; true)$$
$$F2 \triangleq \lceil i \in call \rceil; true \Rightarrow \ell \le t_s \lor (\ell \le t_s; \lceil door = i \rceil; true)$$
$$F3 \triangleq \lceil door \ne i \rceil; \lceil door = i \rceil; \lceil door \ne i \rceil \Rightarrow \ell \ge t_o$$

UNU/IIST will highlight, in its projects and its education courses, instances of such problems and examples of their remedy.

## 5.5  MANAGEMENT

In order to secure timely, economic and manageable development projects, managers must apply resource planning: estimation, risk analysis, allocation and scheduling, resource monitoring and control techniques, and overall quality assurance: planning, monitoring and control.

$$SLC = RD \oplus SD \oplus MKT; \quad MKT = I\&A \oplus U \oplus CT \oplus TA; \quad CT = \neg CF \supset SLC$$

*A software development 'process' diagram spanning a spectrum from application domain modelling, via abstract to concrete programming, and software engineering to project management.*



Software Development "Life— —Cycle" Diagram

$$RD = SNE \oplus BM \oplus F \oplus B \oplus E\&I/F \oplus DE\&PE \oplus CHI \oplus SIM; \quad SD = AS \oplus D_1 \oplus \ldots \oplus D_N \oplus MC$$
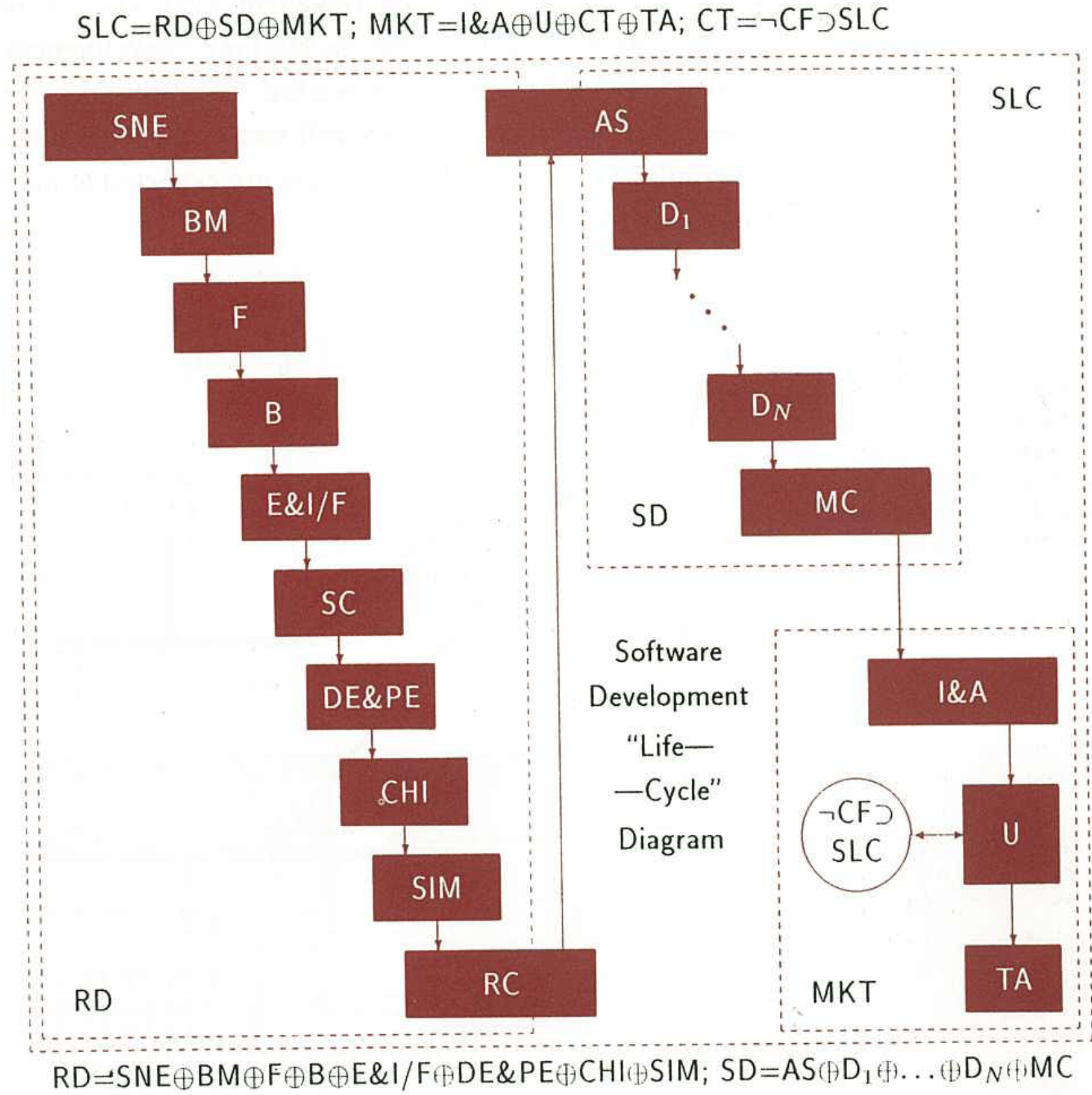
UNU/IIST will, in its projects and courses, propagate state-of-the-art management techniques.

# THE ORGANIC NETWORK OF UNU/IIST

An Organic Network will be linked to UNU/IIST. It will be an expanding net of co-operating software technology development centres, university computation science and engineering departments and academy and industry research institutes. The network will focus on developing country members, but industrialized country affiliates centres are expected to help secure the objectives of the network.

*A diagram showing 2 wide area nets (WANs) connected by satellite communication. To the WANS are connected 3, resp. 2 local area nets (LANs). The figure illustrates the need for an electronic E-Mail backbone for the UNU/IIST Organic Network.*
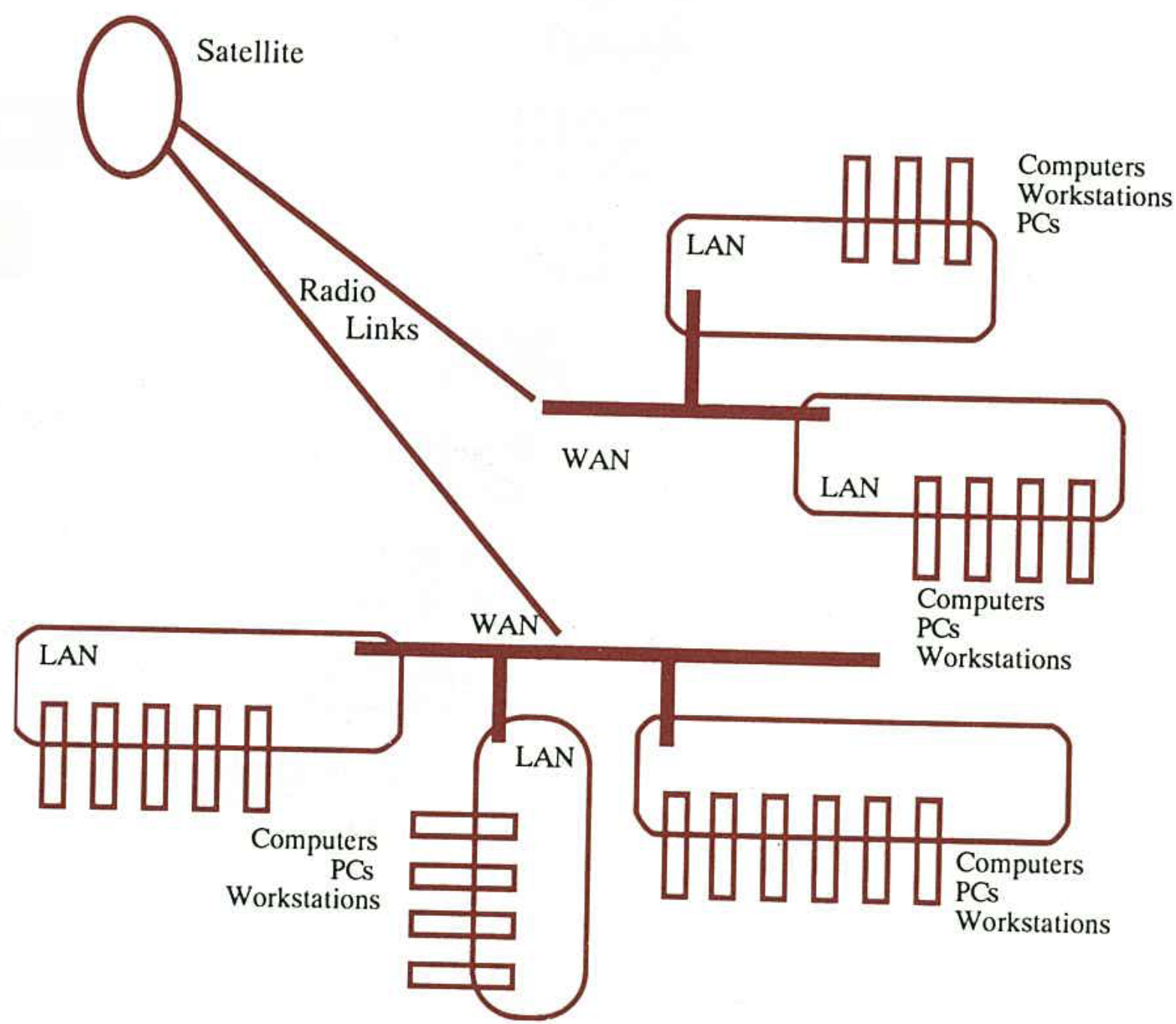


UNU/IIST will never be able to cover all facets of software technology – hence it has to rely on Organic Network Nodes – R&D centers of both developing and industrialized countries – to supplement it. UNU/IIST expects up to a dozen such complementing centres. Nodes are either members or affiliates – as appropriate.

The aims of the network are to strengthen the identity, stability, quality and productivity, in developing country centres, with respect to development projects, university education and research in the areas covered by UNU/IIST .

Means of co-operation are based on the UNU/IIST fellowship programme, rotation of scholars, joint projects, joint courses and seminars, joint events, joint publications, and extensive, timely circulation of the planned Software Technology Monitor, publications, and Public Domain (Free) Software.

*The mix, mix-mix and mix-mix-mix equations illustrate laws of partial evaluation, renditions of Kleenes $S_m^n$ and 2nd Recursion Theorems, and explain basic facets of interpretation, compilation, optimisation and software specialisation. The above formula are basically due to Y. Futamura, A.P. Ershov and N.D. Jones and can be found in: Neil D. Jones, Carsten K. Gomard, Peter Sestoft: Partial Evaluation and Automatic Program Generation, C.A.R. Hoare Computer Science Series: Prentice Hall International 1993, ISBN 0-13-020249-5 (pbk) Sect. 1.5, pages 13-14.*

$$[[mix]\ P\ D]\ S\ =\ [P]\ D\ S$$
$$T\ =\ [mix]\ I\ S$$
$$C\ =\ [mix]\ mix\ I$$
$$CG\ =\ [mix]\ mix\ mix$$



Ole-Johan Dahl
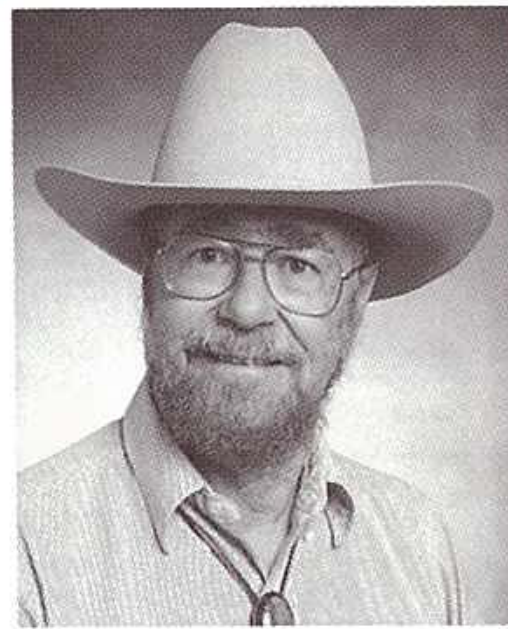


Edsger W. Dijkstra
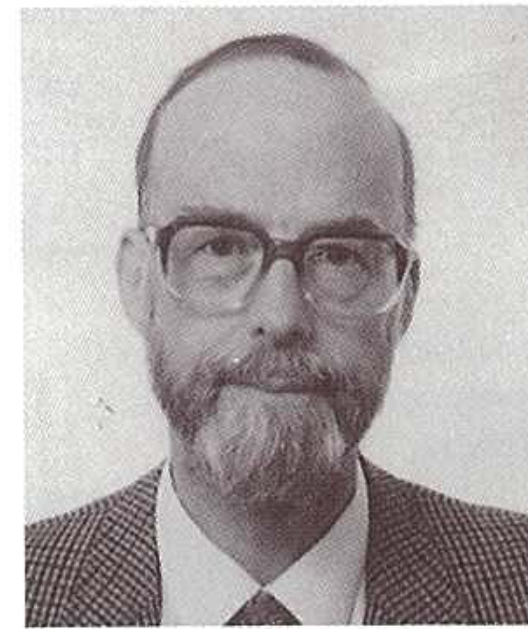


C.A.R.Hoare

*Six contemporary computer scientists whose work form a basis for research & training at UNU/IIST.*



Donald E. Knuth



John McCarthy



Robin Milner

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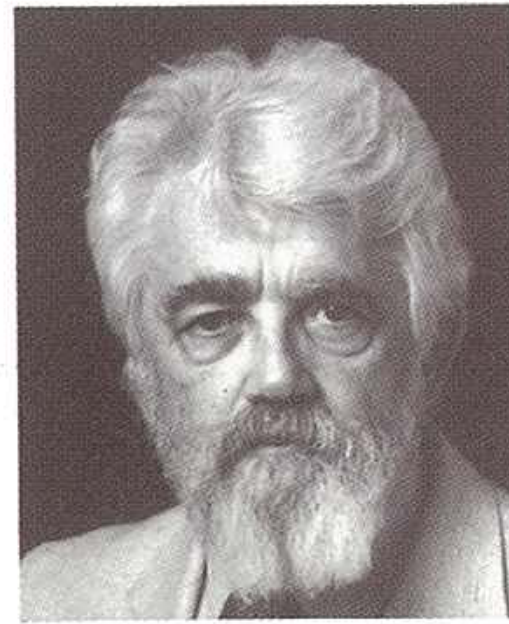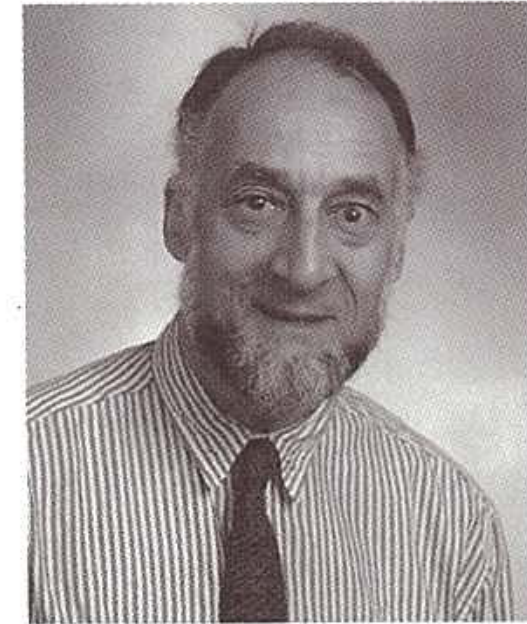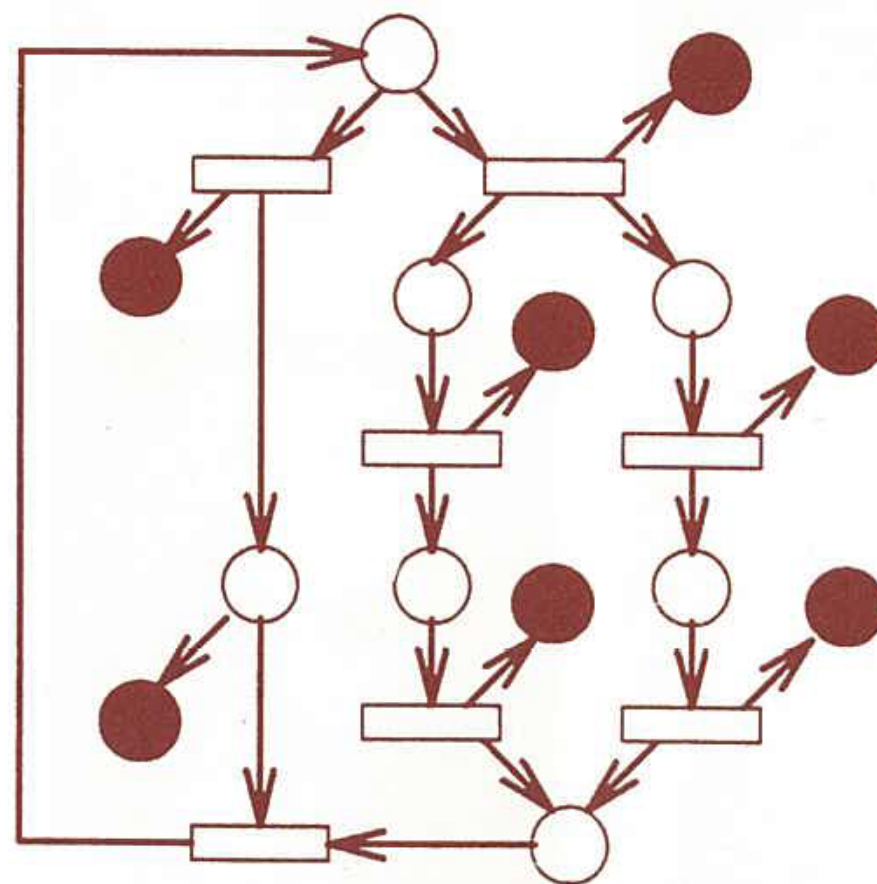UNU/IIST is approaching its task through Master Class, on-the-job training in connection with actual, reasonably scaled exploratory, demonstrator and technology transfer projects which also include tailor-made advanced education courses.

UNU/IIST is geared explicitly to narrowing gaps between theory and practice, and thus between universities and industries, by Case-Study applying front-of-the-wave techniques and tools jointly with industry in developing countries.

UNU/IIST will always remain a small institution when compared to leading university computer science departments and research institutes. UNU/IIST, under the present Director, will try to offset this by two means: (i) focusing on methods, techniques and tools, in short: *Design Calculi* and *Application Domain Modelling*, for the development of trustworthy, embedded systems software, and (ii) mobilizing forces through the *Organic Network Nodes.*

UNU/IIST personnel likewise presents the possibility for novel aspects of co-operation. During the initial build-up phase of UNU/IIST, staff and visiting experts will gradually shift from a majority from industrialized countries, to a majority from developing countries.

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*Petri Nets: their Theory & Practice play an important role in Software.*



UNU/IIST thus differs substantially from most conventional university educational and research systems, also in the industrialized countries.

## INTERNATIONAL FUNDING AND
## DEVELOPMENT ASSISTANCE

UNU/IIST depends, in carrying out a number of its programme activities (notably projects and training workshops), on funding from and collaborative work with the United Nations System: UNDP, UNESCO, UNIDO, WHO, and through The World Bank, and regional development banks such as the Asian, African, European and Inter-American Development Banks.

Typically, such funding is at the country level and reaches UNU/IIST through public and private institutions and companies. UNU/IIST calls upon such developing country recipients of loans and grants to co-operate with UNU/IIST to assist these in better fulfilling their international aid agency supported projects and programmes.

In these and other projects, UNU/IIST is open to or will explicitly rely on industrialized country industry participation in and co-funding of projects, and on business donations for fellowships.

*J. Early's "T" diagrams help explain relations between Specification, Programming, Compiler, Compiling etc. Languages.*

# 9
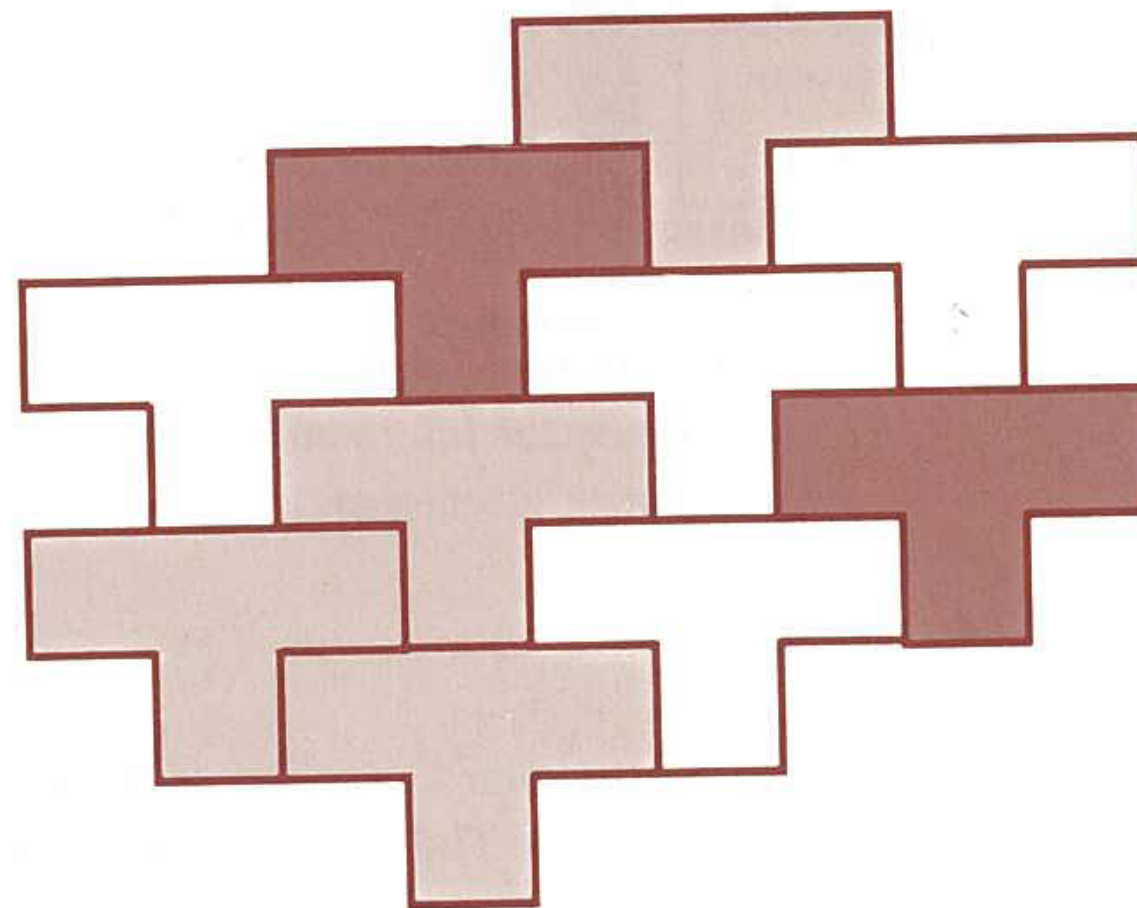
## THE UNU/IIST BOARD

Members of the Board of UNU/IIST are:

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- Professor Dines Bjørner
  Director, UNU/IIST , Macau

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## UNU/IIST INTERFACES

| UNU/IIST | | The UNU/IIST Target World |
|---|---|---|
| **Advanced Development Projects**<br><br>Feasibility, Exploratory, Demonstrator and Technology Transfer | | Industry |
| **Training Workshops**<br><br>Education, Awareness & Instruction | | Users |
| | | **Academia:**<br><br>University Departments and Academy Institutes |
| **Research**<br><br>Individual & Projects | | |
| **Events**<br>Panels, Task Forces, Workshops | | Prof.Societies and Organisations |
| **Dissemination** | | UN System and International Aid Banks |
| **Consultancy** | | |

The UNU/IIST Network

# THE UNITED NATIONS UNIVERSITY

The idea for a *United Nations University* (UNU) was first proposed, in 1969, by then UN Secretary-General, U Thant. The Charter of the UNU was adopted by the UN General Assembly in December 1973. The Government of Japan pledged US $ 100 million to the University; and the UNU . started operations in 1975 in temporary headquarter facilities in Tokyo.
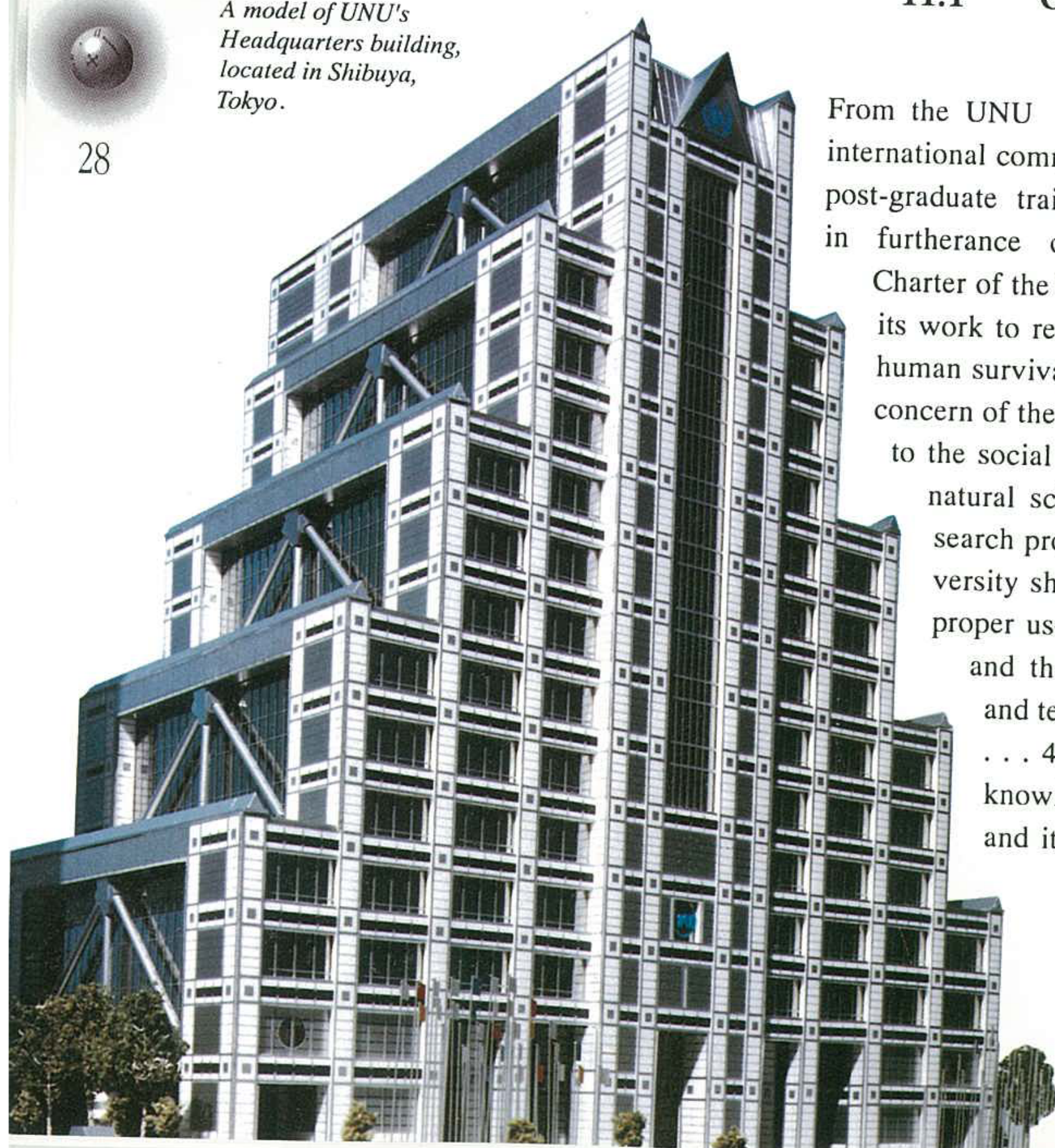
The *UNU* is unique in its approach to the advancement of knowledge. It has no students in the usual sense, it does not award degrees, and it has no central campus. It functions as an autonomous organ of the UN General Assembly: it is not an intergovernmental organization. The academic freedom guaranteed by the Charter enables UNU scholars to collaborate freely.

While the UNU's permanent headquarters seat is in Tokyo, its growing system of research, training and dissemination work ensures that its activities are increasing worldwide.



*A model of UNU's Headquarters building, located in Shibuya, Tokyo.*

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## 11.1 OBJECTIVES

From the UNU Charter: "1. The UNU shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the UN . . . . 2. The University shall devote its work to research into pressing global problems of human survival, development and welfare that are the concern of the *UN* and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied. 3. The research programmes of the institutions of the University shall include . . .the environment and the proper use of resources, basic scientific research and the application of the results of science and technology in the interest of development . . . 4. The University shall disseminate the knowledge gained in its activities to the UN and its agencies, to scholars and to the pub-

lic, in order to increase dynamic interaction in the world-wide community of learning and research. . . . 6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries.. . . It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries. 7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. . . .".

## 11.2    ORGANIZATION

The University Council, which sets principles and policies, has 24 members, appointed jointly by the Secretary-General of the UN and the Director-General of UNESCO for six year terms. They serve in their individual capacities, not as spokespeople for their countries and come from all over the world. The UNU Secretary-General, the UNESCO Director-General, the Executive Director of UNITAR and the UNU Rector are ex officio Council members.

The Rector is the chief academic and administrative officer of the University.

The UNU is organized on a networking principle with the following parts:

- The UNU Centre in Tokyo, the central programming and coordinating body whose academic and administrative staff assists the Rector in the overall direction of the work of the UNU.

- Research and Training Centres and Programmes (RTC/P s), created by the UNU in various parts of the world to focus on specific long-term problems not addressed sufficiently elsewhere.

- Links with universities and other academic and scientific institutions as well as individual scholars and scientists, mainly located in developing countries, to help achieve the objectives set out in the Charter.

## 11.3    FINANCE

Financial support for the UNU and its RTC/P s comes entirely from voluntary contributions from governments, bilateral and multilateral aid agencies, foundations, and other public and private sources. The UNU does not receive any funds from the regular budget of the UN. Major contributions are to its endowment fund, a capital fund invested to yield the basic annual income. The UNU also receives annual-type operating contributions as well as specific programme and project support. As of the 10 Dec. 1993 pledges to the endowment fund and by way of operating contributions from 49 governments and five other benefactors totalled approx. US $ 270 million of which US $ 236 million had been received.

## 11.4    THE UNIVERSITY'S WORK

The UNU work can be identified with the Centre and its RTC/P s:

- At the Centre, or through Programmes directed from the Centre, programmatic activities presently focus on:

    - Peace, Governance and Culture: Governance and Conflict Resolution; Multilateralism and the UN System; Culture and Development.

    - Global Life-support Systems: Mountain Ecology and Sustainable Development; Human Dimensions of Global Change; Energy, Technology and Environment.

    - Science and Technology: Science and Technology for Development;

    - Population, Health and Human Welfare: Food and Nutrition for Human and Social Development; Implications of Demographic Change and Urbanization; Global Change and Modelling.

- At UNU/WIDER: UNU World Institute for Development Economics Research, Helsinki, Finland, programmatic activities focus on: New directions for world economy; Hunger and Poverty — the Poorest

Billion; Money, Finance and Trade: Reform for World Development; Economics of Environment and Development; Security and Development; Women and Development.

- At UNU/INTECH: UNU Institute for New Technologies, Maastricht, The Netherlands, programmatic activities focus on: Implications of New Technologies – effects of international treaties upon developing countries, access to new technologies, effects of economic crises and structural adjustment policies on their technological institutions and capabilities, etc.

- At UNU/INRA: UNU Institute for Natural Resources in Africa, programmatic activities focus on: Sustainable Development in the Humid Tropics – soil and water conservation and management, indigenous African food crops and other useful plants, mineral resources development.

- At UNU/BIOLAC: UNU Programme for Biotechnology in Latin America and the Caribbean, centered at Caracas, Venezuela, programmatic activities focus on: research and training on vaccine development and improved diagnostic methods for human and animal diseases, plant genetic engineering with special emphasis on disease and pest resistance, and improvement in nutritional quality of crops.

More on the UNU

For more information on the UNU in general and its other RTC/P s, please contact the Centre in Tokyo or any of the RTC/P s, at the addresses given on the inside rear-cover of this brochure.

*Portuguese folklore dance in front of the Ruins of St. Paul.*

The Territory of Macau, which includes the peninsula of Macau and two nearby islands, Taipa and Coloane, is situated on the southern coast of China in the western part of the Pearl river delta. The area of Macau is 17 square kilometers. Macau has an almost 400.000 population. Macau is a duty free port with no currency import/export restrictions. Portuguese and Chinese are official languages while English is also spoken.

Founded in the middle of the sixteenth century, Macau has been administrated by the Portuguese for more than 400 years. In 1987, Portugal and China issued a Joint Declaration on an agreement to transfer administration of the Territory from the Portuguese Government to the Chinese Government on December 20, 1999.

From April to September, the weather is very humid and warm with the possibility of July-August hurricanes; from October to December, it is mild and dry; and in January and February, it is somewhat cold and humid; the temperature starts to rise in March while humidity remains high.

Macau is reached from Hong Kong by means of very frequent, boat connections, many making the trip in less than an hour, and by road from Guangzhou (Canton, 160 kilometers).

The main industry (approx. 75%) of Macau is garments and textiles with toys, electronics, leather products, wooden furniture, ceramics and optical products being other important products. Tourism is a strong sector in Macau's economy. In 1991, there were 7.5 million visitors. 81% were Hong Kong residents who came for the casinos.

The business and industry location of Macau is ideally suited – being, as it is, in the midst of one of the fastest growing high technology areas of the world today. Macau has the economic basis for rapid expansion. It represents excellent prospects for investments in technological areas, which are likely to attract talented people, enterprises and ventures that could profit from UNU/IIST.

Macau has a modern infrastructure to which will be added an international airport to open in 1996; an attractive quality of life; an abundance of ethnic restaurants; quaint old, exciting streets with a plethora of original shops: Chinese Ming and Qing dynasty furnitures, ceramics and china,

traditional Chinese medicine, snake and dried fish, etc.; beautifully restored Portuguese style buildings; quiet and scenic islands with beaches and parks; and excellent communication systems.



*A panoramic view of Macau from the Taipa Island.*
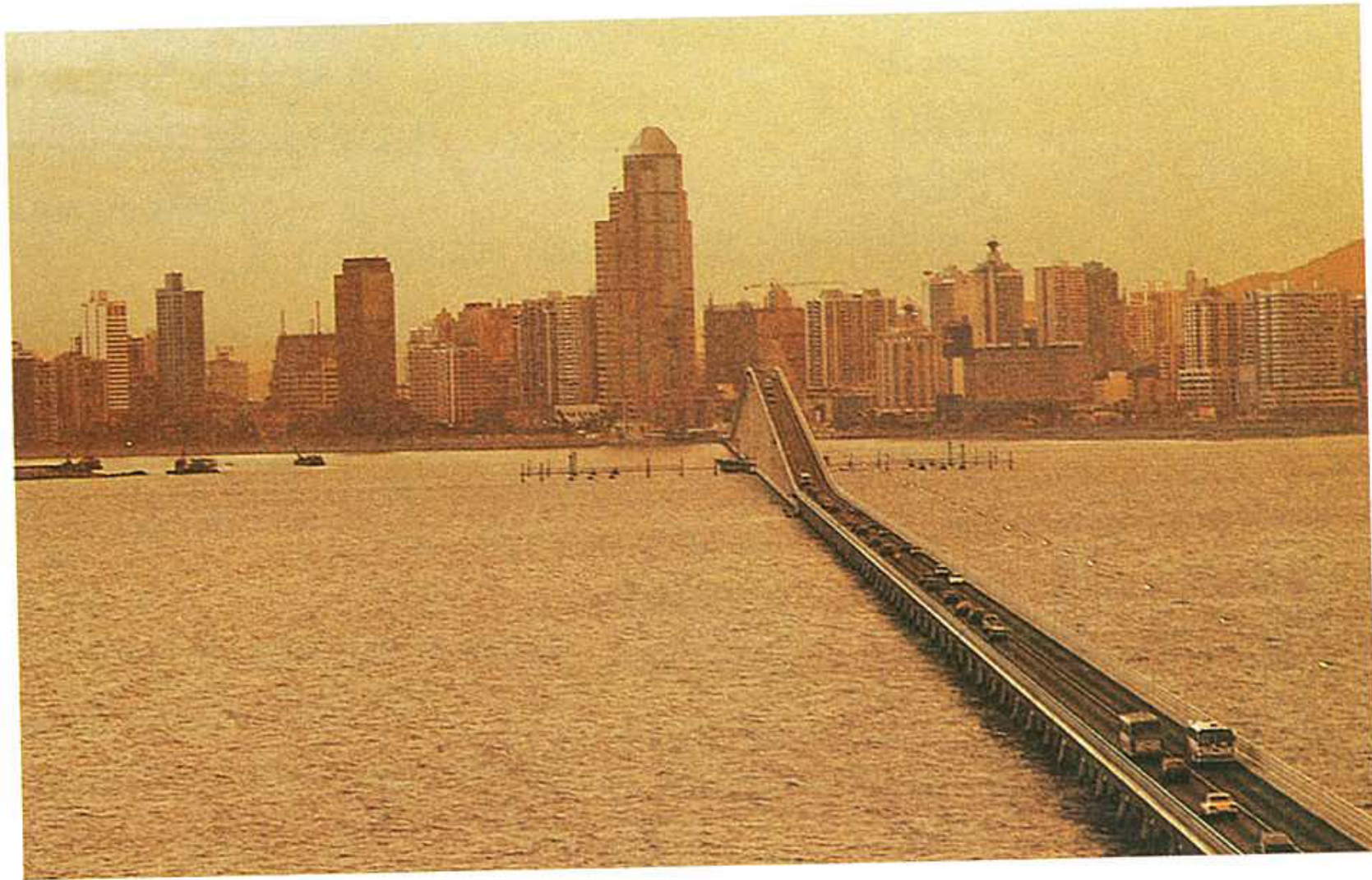
*Interior view of Temple Kun Iam*

*The Guia Lighthouse.*

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## ABBREVIATIONS

| | |
|---|---|
| ADB's: | Asian, resp. African Development Banks |
| AIT: | Asian Institute of Technology, Bangkok |
| B: | The B Method and Tool |
| ESPRIT: | European Strategic Programme for R&D in Information Technology |
| Estelle: | A Telecommunications Specification Language |
| Esterel: | A Reactive Systems Specification Language |
| IBRD: | Intl. Bank for Reconstruction and Development |
| IADB: | Inter-American Development Bank |
| LAN: | Local Area Net |
| Larch: | A Specification and Programming Language Interface Language |
| Lotos: | A Telecommunications Specification Language |
| Modula 3: | An Imperative Programming Language |
| occam: | A Parallel Programming Language |
| Prolog: | A Logic Programming Language |
| RAISE: | Rigorous Approach to Industrial Software Engineering |
| RTC/P: | Research and Training Centre/Programme |
| SDL: | A Telecommunication Systems Description Language |
| SML: | (Standard) ML: A functional Meta (programming) Language |
| TIFR: | Tata Inst. of Fundamental Research, Bombay |
| UN: | United Nations |
| UNDP: | UN Development Programme |
| UNESCO: | UN Education, Science and Culture Org. |
| UNEP: | UN Environment Programme |
| UNIDO: | UN Industrial Devt. Org. |
| UNITAR: | UN Inst. for Training and Research |
| UNU: | UN University |
| VDM: | The Vienna software Development Method |
| WAN: | Wide Area Net |
| WHO: | World Health Organization |
| Z: | The Set oriented software development method |

## UNU/IIST PUBLICATIONS

If you would like to know more about UNU/IIST by ordering its publications, please copy and complete the order form below.

**Please send me the following:**

- The UNU/IIST Annual Report

- The UNU/IIST Programme

- List of UNU/IIST Research & Technical Reports

**Please return to UNU/IIST :**

        Name:
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        Institution/Company:
        Street:
        (P.O.Box:)
        City:
        State/Country:
        Date:
        Fax:
        E-mail:
        Telex:
        Phone:

- Postal address: UNU/IIST, P.O. Box 3058, Macau

- Visiting address: Ed. Banco Luso International, 18/F;
  Rua Dr. Pedro Jose Lobo;
  Macau

- Electronics:
  Phone: +853-712.930
  Fax: +853-712.940
  E-Mail: library@iist.unu.edu
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**UNU World Institute for
Development Economics Research
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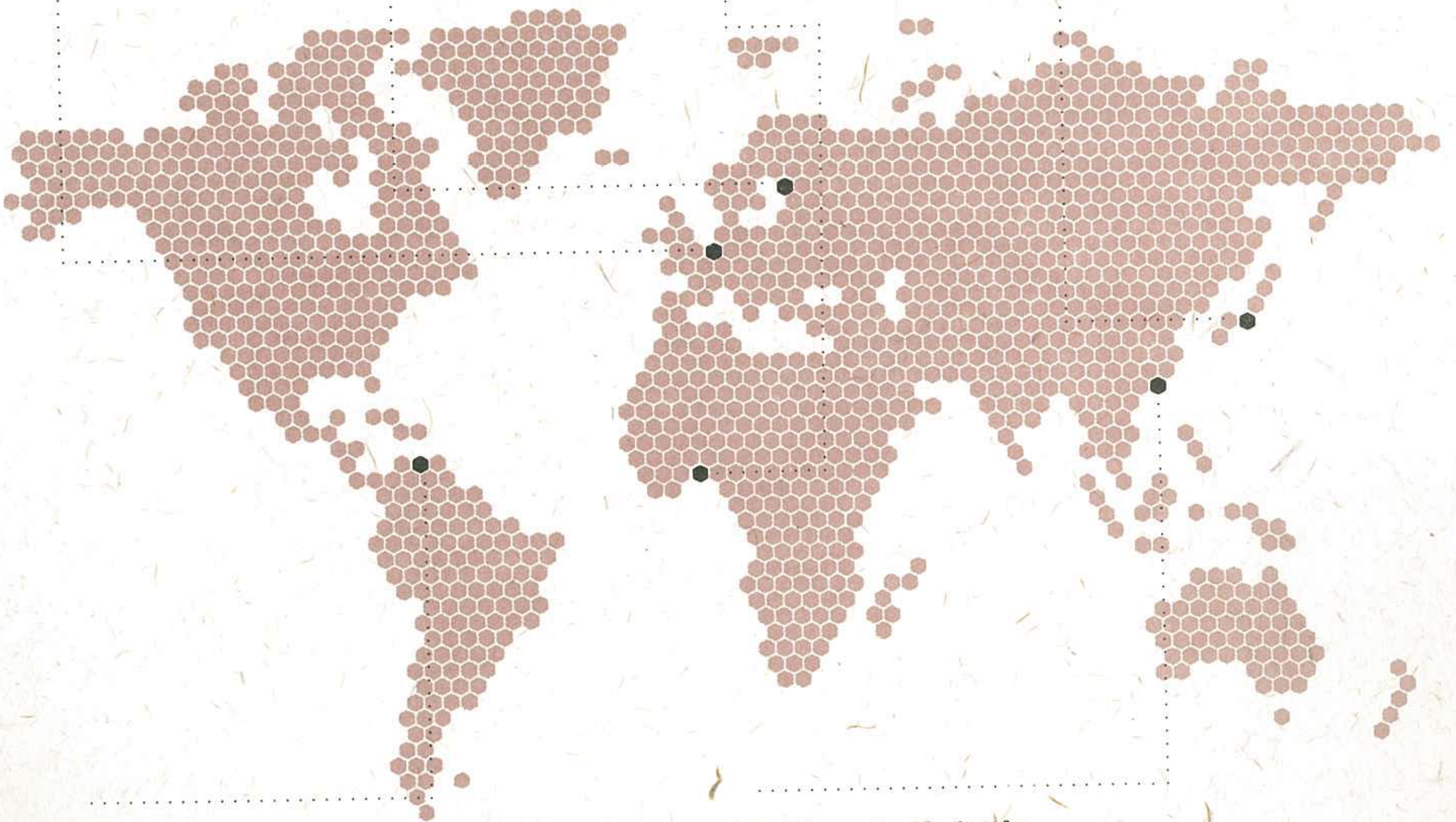
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