FLAGS

"Foundational Aspects
of Global Computing Systems"

Proposal/Contract no.: IST-2001-33116

Global Computing – Negotiation Meeting, 10 Sept 2001, Brussels

Consortium

1. Computer Technology Institute (CTI), leader: Prof. Paul Spirakis (co-ordinator)
2. University of Athens (UoA), leader Prof. Elias Koutsoupias
3. University of Cyprus (UCY), leader Prof. Marios Mavronicolas
4. University of Paderborn (UPB), leader Prof. Burkhard Monien
5. Universitat Politècnica de Catalunya (UPC), leader Prof. Josep Diaz

Summary of Work

We will focus on the following critical aspects of global computing, at a **foundational algorithmic** level :

- the **co-operation and antagonism** in co-ordinating autonomous entities behaving in a selfish way, having their own self-interests.

- the **stability** and fault-tolerance in highly dynamic multi-agent environments.

- the motion, communication and access to advanced services in **ad-hoc mobile networks**.

Multidisciplinary approach

Expected Results

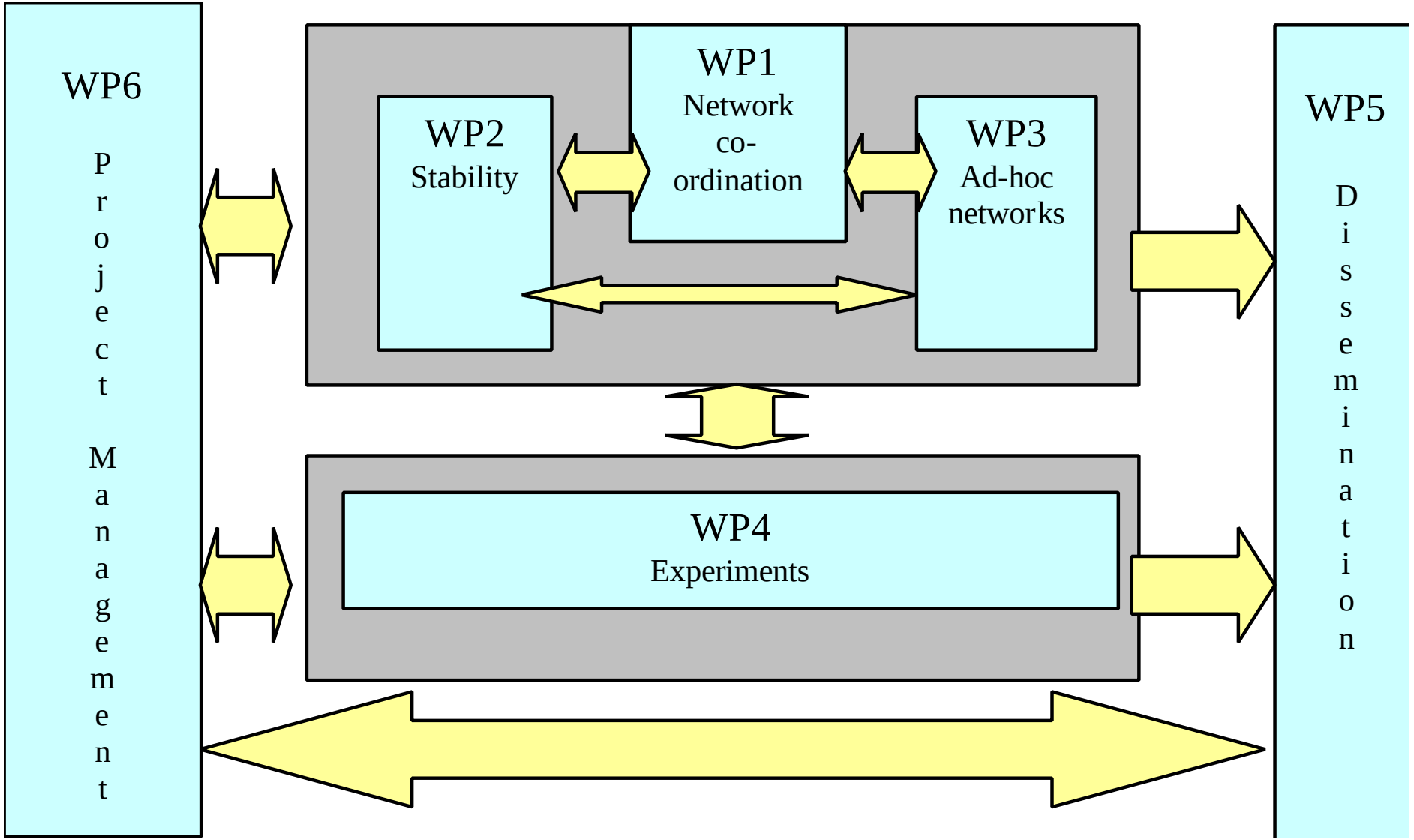
- A **unifying scientific framework** for co-ordination, stability and fault-tolerance, motion and communication in complex and dynamic global systems.

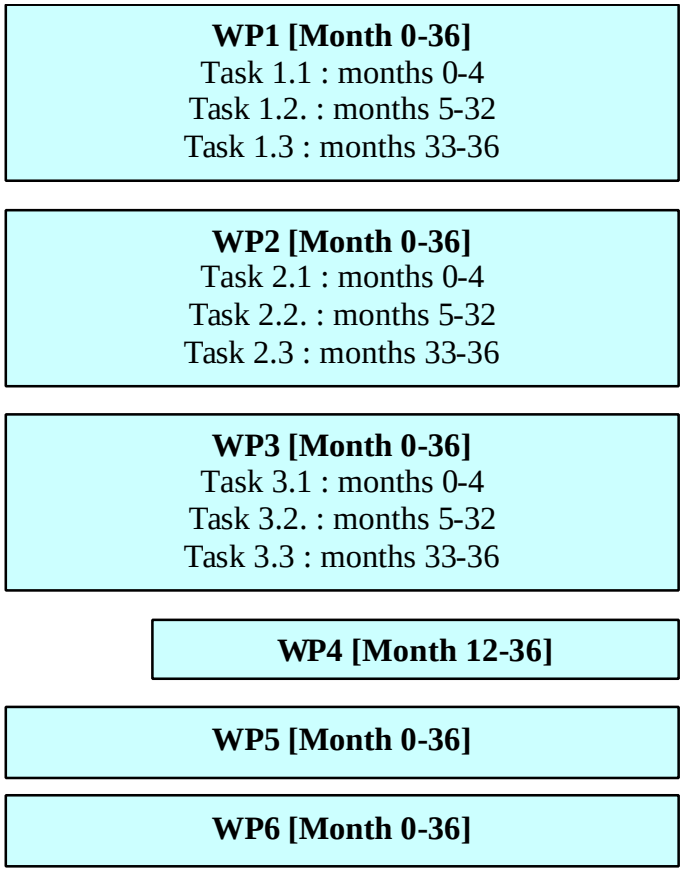
- A **coherent set of design rules and recommendations** for the robust and efficient implementation of global systems.

- A **set of algorithmic engineering experiments**, emphasizing on "hard" instances and appropriate gross measures.

Workpackage List

Work-package No	Workpackage title	Lead contractor No	Person-months
WP1	Co-operation and Antagonism of Dynamic Autonomous Entities	UCY	54
WP2	Stability and Fault-Tolerance of Dynamic Multi-agent Environments	UPC	44
WP3	Communication and Computing in Ad-hoc Mobile Networks	CTI	50
WP4	Experiments	CTI	49
WP5	Dissemination	CTI	20
WP6	Project Management	CTI	8
	TOTAL		225


WP6
Project Management
WP1
Network co-ordination
WP2
Stability
WP3
Ad-hoc networks
WP4
Experiments
WP5
Dissemination



Timing of work

Task x.1: Definition of models, problems and research targets
Task x.2: Production of research results
Task x.3: Conclusions and technical recommendations

WP1: Co-operation and Antagonism of Dynamic Autonomous Entities

A natural framework in which to study **multi-objective optimization problems** in non-cooperative communication networks with local payoffs is (non-cooperative) **game theory**. An appropriate, game-theoretic concept for the solution is **Nash equilibrium**. Roughly speaking, the operating points of a non-cooperative network are the Nash equilibria of the underlying game; these are points where unilateral deviation does not help any user to improve its performance.

Till now, Game Theory was, by large, **not computational**. We aim in introducing **a new spirit** to the cooperation of Computing and Game Theory, in the sense that we not only use such tools in order to estimate the performance of entities under antagonism but we will also use **mechanisms** to partially control equilibriums and affect global behaviour towards best performance.

Game-theoretic models, concepts and techniques will be employed in the context of various networking problems such as **flow control, routing, bandwidth allocation, Web access, multicasting and congestion control**.

WP2: Stability and Fault-Tolerance of Dynamic Multi-agent Environments

We will investigate dynamic situations where **computing agents move around** in a global environment trying to communicate and compute quickly having only partial knowledge of the system.

Bad transient behaviour of such global systems may be represented by malicious **adversaries**.

To study **performance** under these conditions, we will investigate **stability** and fault-tolerance in a novel way:

- models for such dynamic communication systems
- criteria for stability
- queue priority protocols

WP3: Communication and Computing in Ad-hoc Mobile Networks

To provide a solid scientific foundation for highly mobile ad-hoc networks, we will develop:

– **novel algorithmic ideas**, such as **semicompulsory** approaches exploiting **the co-ordinated movement** of a small part of the hosts in the network, that form a moving **"support"** that sweeps the space and acts as an intermediate pool for receiving and forwarding messages.

– **new models**, such as **motion graphs** abstracting the geographical area the network covers and the movement of hosts in this area.

– **novel use of advanced techniques**, such as **random walks** techniques, strong stationary time sequences and stopping times as well as theory of particle interactions in finite domains.

We will propose reliable and efficient protocols for a variety of problems (end-to-end communication, broadcasting, load balancing, routing etc).

WP4: Experiments

The experiments will be implemented in a **uniform platform**, integrating a) a **high level language** (such as C++, Java) and b) a **network simulator** (such as the open source Berkeley LBLN Network Simulator). This uniform **software implementation** of experiments will enable **scalability**, **big enough sizes of inputs** and **synergy** between certain research themes.

The experimental work proposed in this project will **use novel algorithmic engineering techniques**, such as that of **identifying "hard" instances** as inputs to the experiments, to reveal the worst-case complexity of the problems.

Also, this experimental research will combine techniques from different disciplines (Physics, Economics and Game Theory) to introduce **appropriate gross measures** (such as injection rates, rate of collisions, motion speeds) to characterize performance in complex dynamic systems of a global nature.

WP5: Dissemination of results

- **publications** in major, influential and highly competitive conferences

- organization of **highly specialized workshops**

- arranging **schools** for training young researchers in Europe. These schools are expected to have a duration of one week, there will be around 4 invited speakers teaching in each school 6-8 hours, based on well prepared notes and carefully designed exercises.

- **dissemination through the Internet**. A **WEB server** of the project will be enriched with the **published papers** and technical recommendations during the various stages of the project. It will also contain a **project description**, the list of participants and their contact points. It will include a **searchable database of technical reports** produced within the project and other related material.

WP6: Project Management

The project management is divided between:

1. the **Project Steering Committee** (PSC)
2. the **Technical Committee** (TC)

Parameters and Criteria for **Self-assessment**
Annual Self-assessment reports

Main References

E. Koutsoupias and C. Papadimitriou. Worst-case equilibria. In the Proceedings of the16th Annual Symposium on Theoretical Aspects of Computer Science (STACS) 1999.

M. Mavronicolas and P. Spirakis. The price of selfish routing. In the Proceedings of the 33rd Annual ACM Symposium on Theory of Computing (STOC), 2001.

A. Borodin, J. Kleinberg, P. Raghavan, M. Sudan and D. Williamson. Adversarial queueing theory. In the Journal of the ACM, 2001.

J.Diaz, D. Koukopoulos, S. Nikoletseas, M. Serna, P. Spirakis and D. Thilikos. Stability and non-stability of the FIFO protocol. In the Proceedings of the 13th Annual ACM Symposium on Parallel Algorithms and Architectures (SPAA), 2001.

I. Chatzigiannakis, S. Nikoletseas and P. Spirakis. An efficient communication strategy for ad-hoc mobile networks. In the Proceedings of the 15th International Symposium on Distributed Computing (DISC). 2001. Also invited paper in the 1st ACM Workshop on Principles of Mobile Computing (POMC) 2001.

Robert Els"asser, Burkhard Monien, Robert Preis. Diffusive Load Balancing Schemes on Heterogeneous Networks. In the Proceedings of the 12th ACM Symposium on Parallel Algorithms and Architectures (SPAA-00), 2000.