INFORMATION SOCIETIES TECHNOLOGY
(IST)
PROGRAMME

Contract for:

Shared-cost RTD

Annex 1 - "Description of Work"

Project acronym: **iCities**
Project full title: **Information Cities**
Contract no.: ***IST-1999-11337***
Related to other Contract no.:

Date of preparation of Annex 1: **19.10.1999**

Proposal number*:* ***IST-1999-11337***
Operative commencement date of contract: *see Article 2.1 of the contract*

Contents

1 Project summary

Project Acronym (2)	iCities	Proposal No (3)	IST-1999-11337
A2.	**Project Summary (20)**		

Objectives (maximum 1000 characters)

The objective of this project is to explore and validate models for the creation and formation of Information Cities over the emerging Information Infrastructure by using analogies and patterns of aggregation/segregation of inhabitants in current Physical Cities, Business Districts and Urban Communities. Towards this objective we will: i) create new formal models (e.g. behavioral models for infohabitants) to study the formation of Information Cities, ii) investigate the fundamental forces and dynamics for the stability and evolution of Information Cities, and iii) develop an open simulation and emulation environment to study emerging behaviors and structures, and their evolution in time and space.

Description of work (maximum 2000 characters)

The Information Cities Project Workplan consists of five Workpackages (WPs), spanning 36 months. Deliverables will either be reports or software prototypes.

By surveying the field of self-organization and coalition formation theories, WP1 will provide the theoretical input for the research undertaken in this project and the necessary formal principles to elaborate models able to capture aggregation/segregation patterns in a virtual world. WP2 will design behaviors for infohabitants (based on rules such as "bounded rationality", learning and adaptation) and will provide a set of algorithms capturing these behaviors; it will also describe formal structures (communication channels) which may carry later, during the implementation phases, interactions among infohabitants. WP3 will provide a multi-agent system that can serve to realise the algorithms and models defined in WP1 and WP2, for the purposes of experimenting with these models and observing patterns of aggregation/segregation. WP4 will emulate the models defined in WP1 and WP2, using the multi-agent system built in WP3. Work in this final stage of the project consists of: i) experimenting with alternative scenarios of evolution (with and without intermediaries) to capture patterns of aggregation/segregation, yielding large and complex, virtual, spatial structures, such as Information Cities and virtual business districts, and ii) analyzing via simulations further transformation and competition between Information Cities. Finally, WP5 will carry the management activities of the project (administrative and technical management).

Throughout the duration of the project, reports and other forms of publication, as well as two Workshops, will serve as reference material and communicate into the scientific community and other audiences the results of the work.

Milestones and expected results (maximum 500 characters)

By analyzing and emulating dynamic, emergent properties of the Information Infrastructure, this project will contribute to: i) understanding what the collective organizational structures of the Information Society and Economy will be like, and ii) design principles/guidelines for agents, electronic markets, and electronic institutions, such as virtual firms, business districts and Information Cities, that foster efficient electronic transactions and effective interactions between infohabitants.

2 Project Objectives

The objective of this project is to explore and validate models for the creation and formation of Information Cities over the current ubiquitous Information Infrastructure by using analogies and patterns of *aggregation/segregation* of inhabitants in current Physical Cities, Business Districts and Urban Communities. Towards this objective we will:

1. Create new formal models (e.g. behavioural models) to study the formation of Information Cities.
2. Investigate the fundamental forces and dynamics for the stability and evolution of Information Cities.
3. Develop an open simulation and emulation environment to study emerging behaviours and structures.

We envision that we can apply our models, experimental results and emulation environment to the creation of real-world information cities, towns and villages, which we expect to thrive in large numbers over the Internet.

2.1 Background

Over the last few years, we have witnessed the first steps in the evolution of the Information Infrastructure, currently exemplified by the first generation Internet and World Wide Web, where several infohabitants (humans mainly and software entities acting on behalf of humans) have performed various economic and social activities such as building communities of interest, buying and selling goods and services, organising information groups and scientific community networks. Examples include, community and information Portals, electronic marketplaces and trading places, which bring together a large number of infohabitants who share common interests, derive some economic and social value, and conduct trade with various other infohabitants. These phenomena remind us of the behaviour of humans in the real world where towns, cities, business centres, marketplaces, and social communities are formed for various economic, social and political reasons.

How these trends may evolve in the future? With a little of speculation, we may envision some possible future worlds with specialised virtual valleys of economic activity, virtual agglomerations and electronic neighbourhoods...

Possible Future 1: Modern Information Infrastructure is emerging as an open, flexible and effective environment for many aspects of the human economic and social life (from electronic commerce to distance learning and on-line entertainment). How do these emerging information-based economic and social activities organise the use of the virtual space? Is it possible that a kind of economic geography appears for these virtual activities, giving rise for example to *developed* and *less-developed* regions of the Web or to *specialised virtual valleys* (i.e., virtual Silicon Valleys) for particular industries and business domains?

Possible Future 2: A vision for the future of the Information Infrastructure, as defined by this Initiative, conceives the emerging Information Society as an "ecosystem that constantly scales up or down, evolves and adapts in order to best meet the changing demands of its vast and highly dynamic population of infohabitants". But physicists and biologists know with certainty that ecosystems, i.e. large interacting ensembles, exhibit collective behaviour that is very different from anything you may obtain by simply scaling up the behaviour of the individual units. It is therefore natural to ask which forms of complex organisation will emerge from the interaction between inhabitants of the cyberspace and how effective and efficient will be? Should, for example, one expect the "individualisation" of the virtual space through the instantaneous development of direct relationships among individuals and the establishment of direct links between buyers and sellers of information and traditional goods? Or will other, collective, forms of organisation will progressively dominate this space? Which ones exactly? Might we envision, for example, a virtual world with interdependent electronic markets, intermediaries and other collective institutions (such as on-line co-operatives of customers negotiating better prices and services) continuously aggregating to form *virtual agglomerations?*

Possible Future 3: According to French sociologist Jacques Attali, life in modern societies becomes more and more *nomadic*, as people increasingly move from one place to another for work or frequently travel for personal and professional reasons [1]. This inevitable trend, European policy makers argue, should be reinforced: the mobility of workers appears to be a necessary structural reform to strengthen the new currency [2]. How will Information Infrastructure deal with these nomadic lives and habits? Would people need as a counterpart in their nomadic life, a certain virtual stability? Would they for example need some kind of permanent affiliation, independently of where people are physically located, to a familiar virtual entity (i.e., a stable provider of complex personal and community services), a kind of *electronic neighbourhood* for modern nomads?

Research questions:

- What causes Information Cities to be formed naturally and survive?
- What patterns of social and economic organisation will emerge within Information Cities? Can we start building them? Which new, if any, software architectures and services will be needed?
- In the real world, spatial structure (i.e. the location of the economic activity or, putting it in another way, the "geography of the economy") is the outcome of a process characterised by interesting empirical regularities and unexpected behaviours at the aggregate level. To explain these intriguing phenomena, a long intellectual tradition in economic geography has been progressively established, providing interesting insights into the formation and evolution of patterns of spatial organisation[1]. Will the virtual world exhibit similar regularities and unexpected aggregate structures, as the above lines may implicitly suggest? How can we prove it? And, if this is the case, which are the appropriate intellectual models and prediction tools helping to envision and explain the emergence of patterns of organisation in the virtual space?

[1] For a survey, see [3]

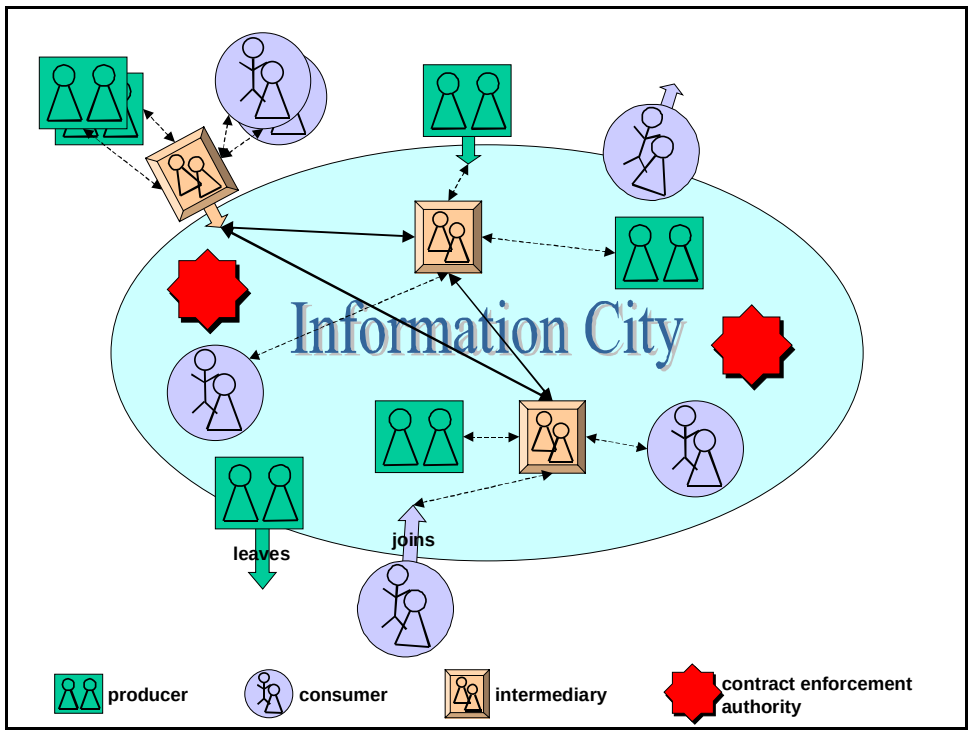
2.2 Objective I: Reveal aggregation/segregation trends in virtual space

How should we deal with patterns of organisation in the virtual space? We start with an assumption: the Information Economy is, self-evidently, a self-organised system, with complex behaviours similar to those demonstrated by other large, complex, self-organised systems, as for example hurricanes, animal species, urban economies, stock markets etc. In fact, a growing cyber-economy will give rise *to emergent phenomena*, i.e. system-wide behaviours that are difficult to predict from the actions of the constituent parts (in the same way that an anthill could not be predicted by studying individual ants).

Many people who think about the evolution of such self-organised systems consider *tagging* as a very important property [4]. The term signifies the existence of an inherent trend to form aggregate structures by promoting global or selective interaction (aggregation and segregation, correspondingly). There is no reason why the Information Infrastructure, seen as a large scale Ecosystem, comprising of huge numbers of infohabitants, should not show similar trends.

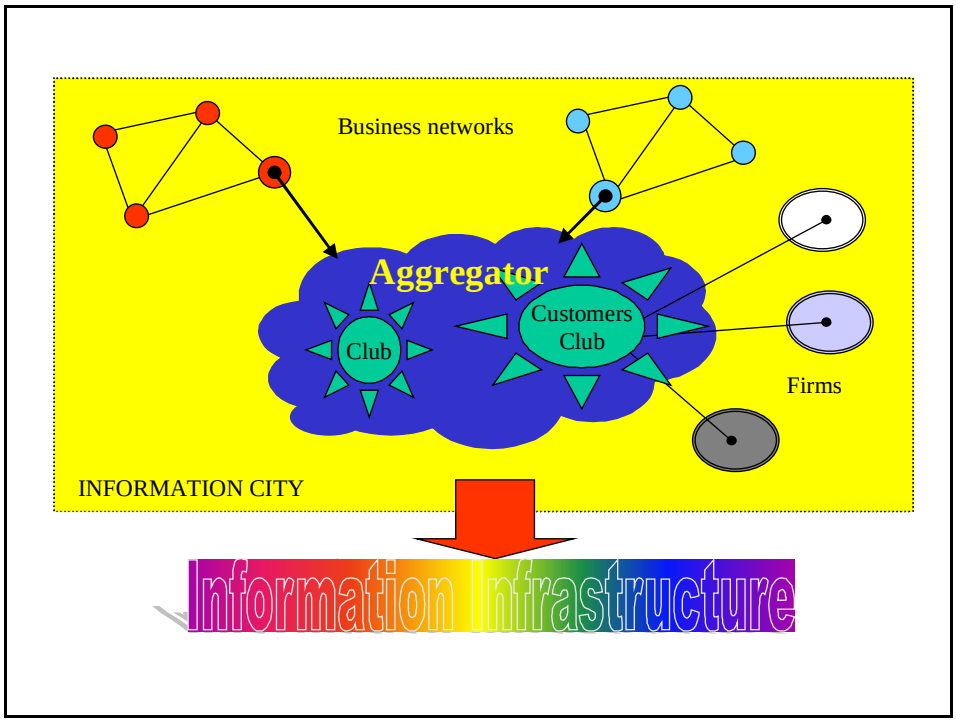
We will offer two examples to illustrate aggregation and segregation dynamics: i) portals and, ii) scientific networks. Portals, in their current form, aggregate and organise as much information as possible about products and services, thereby becoming online reference places where millions of people like to congregate [5] on a day to day basis. On the other hand, electronic scientific networks, based primarily on the use of e-mail, are growing both in number and extent. These networks, though closing the geographic distances among physically separated scientists, seem to result in segregation into distinct groups of scientists according to criteria such as "subject space" and "quality level" [6].

In an electronic world, aggregation and segregation may yield different organisational outcomes, from composite objects to complex structures, as virtual networks of firms (virtual business districts) and Information Cities: cyber-places where millions (or billions) of infohabitants (humans, businesses and social organisations and software agents acting on behalf of them) meet each other, co-operate and trade. They may emerge within the Information Society as stable and scalable microenvironments that support the efficient provision of many e-commerce and personal services and allow for the continuous creation of new activities and relationships. By analysing patterns of aggregation/segregation in the virtual space, this project will address the question of virtual agglomerations, Cities and business districts, their formation and evolution in time and space.



We define an *information city* as comprising of:

- **a dynamic collection of interacting infohabitants, such as: information consumers and producers, aggregators, other value-added service providers (as banks, credit agencies etc.), enforcement authorities etc.**
- **a dynamic collection of sharable resources, information content and services**
- **a trust framework for building business and community relationships.**



2.3 Objective II: Capture and emulate patterns of virtual organisation

A multiagent system will be employed to emulate relationships between *infohabitants* (i.e. humans and software agents) and capture long term patterns of organisation in the cyberspace. It will provide the environment for:

1. Instantiating behaviours for humans and software agents and rules of interaction between them
2. Realising constraints (i.e. voluntary commitments) and dependencies (i.e. reciprocal engagements, affiliation contracts including authorisation and access rights etc.), as in the real economy
3. emulating behaviours, constraints and dependencies and observe emergent structures and their evolution in the time.

Our focus is twofold:

1. how to capture emergent phenomena in the continuously evolving Information Infrastructure, especially aggregation/segregation trends and formation of collective structures, as Information Cities. For this, we will observe trends in the real-world information economies (as described in the first set of objectives) and apply models from economics and behavioral science to develop behavioural rules which then could be analysed and simulated and new emergent behaviors could be observed.
2. how to evaluate the stability, survival and dynamic evolution of these structures in the long term.

As a result, the design of the multiagent system will proceed in four stages:

1. Consider a space with interacting agents (consumers and producers) and observe patterns of interaction
2. Introduce a new agent category, i.e. intermediaries, and observe modification in trends
3. Investigate the emergence and stability of more complex intermediary structures, as Information Cities providing services and conditions of trust to their infohabitants (examples of these services should include banking, registries, contract enforcement… etc.)
4. Further study the evolution, internal organisation and competition between Cities.

We present a brief explanation on how to accomplish the above objectives. In the later sections, we provide a detailed approach. Our approach is based on modeling the Information City and the infohabitants behavior by using principles from economics and behavioral science. The models are not only driven by observations from the real world information societies, but also projections of expected behavior from infohabitants in the information cyberspace. Using our models, we will then analyze the behavior using the following:

1. Analytical tools (e.g. dynamical equations) and corresponding numerical results.
2. Simulation of the Information City (with the models) and then observe behavioral patterns (e.g. stability of the city, migratory behavior, herd mentality and so on) emerging from the simulation.

3. Emulation of the Information City: we will implement a simple information city using a distributed software system. We will use techniques from experimental economics to analyze the behavior of real human beings participating in the information city. We will develop software components that will emulate the functionality of services developed in real-world electronic commerce systems, so as to enable a realistic study of interaction dynamics.

The whole system will be flexible, scalable and adaptive so it can be tailored to the dynamic nature of the Information Economy and Society where new types of relations and activities are continuously emerging.

Scalability[2] will be achieved using the following techniques: 1) numerical equations to capture the behavior of the infohabitants. With these one can study the behavior of millions, if not, billions of agents in a well defined environment. The simulation will be event and/or time-based; 2) We will also use a multi-agent platform, where threads within processes can model the behavioral rules of infohabitants. We can model thousands if not, millions of infohabitants using these threads; 3) we will decentralize and decompose the models in such a way that the multi-agent platform can be replicated across multiple computing machines. We could then implement one or more information cities as decentralized systems.

For adaptability the following is the procedure: 1) We will use learning rules and models of bounded rationality to adapt to changes in the environment parameters of the information city; 2) We will vary the degree of adaptability of the infohabitants based on the complexity of learning and memory retained.

Given the space of decision variables and decision rules of the infohabitants, we expect to observe evolutionary behavior among the infohabitants[3]. For this, we will provide tools to observe individual as

[2] By allowing multiple levels of aggregation-segregation, the techniques we will use assure in-vivo scalability.

[3] Evolutionary behavior implies that there is learning involved from the interaction with the environment. This learning may lead into "mutations" of the species, or even the emergence of an altogether new species. To avoid cycles of births and deaths, generations and populations, we may think in terms of "immortal" economic agents that may coincide, for the purposes of this discussion, with biological species. One could think of various categories of economic agents in the Information Cities: consumers and providers of various information goods and services, chains of such agents, virtual firms etc. They have - initially - simple behaviors (goods they possess or services they offer, patterns of buying and selling, etc.) but they also have a set of learning rules that can alter the behavioral rules to assure survival and adaptation to market-selection mechanisms, i.e. non-starvation from lack of funds. Finding such learning rules, making them as generic as possible and as simple as possible, is one of the research issues that will be addressed in this project. Another related question is whether these learning rules can lead to emerging behavior that is dishonest, malicious, etc., and then according to which ethical rules.
One could also think of learning rules that would lead to aggregation of economic agents (for example within portals), which in turn could be considered to be (derivative) economic agents in their own right with their own evolving behaviors and learning rules. Portals are expected to aggregate into Information Cities which also behave as economic agents and have to fight for survival fighting against other Information Cities. The more interesting research question is whether we will observe in the Information Cities, emerging structures, similar to the ones in geographical cities: segregation of activities (business districts, residential areas, etc.) policing functions, trust management, banks, stock markets etc. The question is whether these structures could emerge either out of mutations of i-Cities constituent agents (such as simple economic agents, portals, virtual firms etc.) and/or out of mutations

well as (e.g. economic parameters) the collective behavior of infohabitants (e.g. economic and behavioral indicators), and stability indicators of Information Cities.

We hope that insights gained by this work, by analysing and emulating the dynamic, emergent properties of Information Infrastructure will lead to:

i) understand what the collective organisational structures of the Information Society and Economy will be like and,

ii) design principles/guidelines for agents and electronic markets (and other electronic institutions, as virtual firms, virtual business districts and Information Cities) that foster efficient electronic transactions and effective interactions between infohabitants.

of the i-Cities themselves. And whether all of these more and more complex structures could emerge out of some initial simple economic agents endowed with simple rules of behavior and simple learning rules that will allow them to show evolutionary behavior.

3 Participant List

List of Participants

Participant Role	Participant number	Participant name	Participant short name	Country	Status*	Date enter project	Date exit project
	1	University of Crete	UoC	Greece	C	M1	M36
	2	Foundation for Research and Technology	FORTH	Greece	P	M1	M36
	3	Swedish Institute of Computer Science	SICS	Sweden	P	M1	M36
	4	Association pour la recherche et le developpement des methodes et processus industriels	ARMINES - Econometrie	France	P	M1	M36
	5	International Business Machines Corp., Research Division, T.J. Watson Research Center	IBM - IAC	USA	P	M1	M36
	6	Ecole Polytechnique - Laboratoire de l'Econometrie	X - Econometrie	France	P	M1	M36

4 Contribution to programme/key action objectives

The proposed project aims to contribute to a vision on how the emerging Information Infrastructure might evolve in the next few years. We envision a world a decade from now in which billions of software agents will act as economic players on behalf of humans or human organisations (firms, communities etc.), exchanging information goods and services with humans, organisations and other software agents. Starting from this generic assumption, the project will investigate trends of aggregation/segregation in the cyberspace, to explore the potential emergence of complex virtual structures, such as Information Cities and virtual business districts. To achieve this objective, we will take an interdisciplinary perspective, exploring as much as possible analogies from the formation and evolution of cities in the real world.

The *Information Cities* project stems from a perception of the Information Infrastructure as an ecosystem that constantly scales up, evolves and adapts in order to best meet the changing demands of its infohabitants. Within this complex, fast growing and changing mega-environment, Information Cities may create stable micro-environments for any infohabitant (individual or organisation) who wants to join, by supporting the efficient provision of many e-commerce and personal services and allowing for the continuous creation of new activities and relationships. Information Cities may be a novel paradigm of virtual organisation exhibiting:

1. Self-organisation: Continuous aggregation of activities, an obvious trend, may generate large-scale order and stable structure.
2. Path-dependence: Aggregation trends give also rise to a cumulative process of self-reinforcing growth, so small differences in initial conditions can have large effects on the long run outcome and influence the patterns of competition between cities.
3. Openness and evolution coming from inside: Rich information flow within cities and awareness of the demands and profiles of other infohabitants may create spontaneous segregation of activities and then permanent reconfiguration of existing structures (segregation results when people and companies make choices about virtual neighbours and partners).
4. Scalability and adaptation to the external environment: Continuous effort to attract new inhabitants (thus reinforcing positive network externalities for the existing ones) should require good adaptation mechanisms able to continuously discover new opportunities and deal with competition from other locations.
5. Efficiency: Multiple and standardised communication channels between infohabitants of the same city should provide an infrastructure allowing for easy contracts formation between economic agents (businesses and individuals), and continuous control over execution of contract rules with help from software agents.

Explore the emergence conditions of these properties under well-constructed and elegant behavioural models for infohabitants, is an interesting research challenge. This project has the ambition to meet the objectives of the Initiative by providing results contributing to a realistic picture of the evolution of the Information Economy and Society's virtual spatial structure and suggesting some of the emergent properties which the global Information Infrastructure may manifest. Our work may also contribute to the definition of policies encouraging the design of a rich, adaptive, efficient and open Information Infrastructure.

5 Innovation

In this project we propose heuristic approaches to the development of behaviours for infohabitants (humans and software agents acting on behalf of humans or on behalf of virtual organisations) with the objective to capture complex patterns of organisation in the cyberspace, emerging from the interaction among large numbers of infohabitants. We will explore and advance theoretical (e.g. behavioural) models providing insight in emergent phenomena[4], especially in the area of economic geography[5], and apply them to model emergent behaviours and aggregate-level structures in the Information Society and Economy[6].

5.1 State-of-the art

In the real world, most relationships among humans, including the economic ones, acquire quickly a primarily social character; they become embedded in networks structures[7]. In a similar way, recurring patterns of interaction should bind infohabitants together into networks. In such networks, agents learn from each other, and their values, decisions and actions may be influenced by others values, decisions and actions. The process of learning and reciprocal influencing through the interaction networks in which agents are embedded may have important economic consequences: unintended, unexpected outcomes and out-of-equilibrium dynamics (as a result of a permanent, endogenous, discovery of novelty)[8]. For example, in the spatial economy of the real world, the dynamics of interaction among neighbours may explain the emergence of geographical segregation: interdependent individual «small» decisions produce unexpected emergent behaviour at the aggregate level. In turn, under certain circumstances, any initial distribution of agents (individual or business) across the landscape of a metropolitan area, will spontaneously evolve into a highly structured pattern with a small number of clearly separated residential and business districts [8, 9, 22] (segregation). Then, agents' choices embedded in these structures[9] may further change this situation: an aggregate-level pattern of segregated districts seems finally to emerge.

[4] For an overview of the behavioral models we are envisaging to explore and further advance, see in particular: [7].
[5] References on work in this area should include: [3, 8, 9, 10, 11, 12]
[6] Our approach is inspired by recent work in the area of Information Economies; for more details, see: [13, 14, 15, 16, 17]
[7] There is an extensive literature on interaction networks. Representative references include [18, 19]; for a survey, see [20]
[8] To learn and to adapt, agents use a variety of distributed cognitive processes. Agents therefore differ considerably from each other in the way they interpret the world and, as this world is ever changing (because it is continuously transformed by the presence and actions of other agents), rationality is "local" and "bounded", not perfect and optimal – to use social sciences jargon. Compared to more traditional approaches, expecting the full existence of aggregated-level equilibria, the above set of hypothesis seems to give rise to models better accounting for the emergence of new kinds of entities, patterns, structures [7, 21].
[9] To give an example of embeddedness of humans' choices, the size of the population in an existing location may attract new inhabitants from close neighborhoods. But it may also create for others, a need for separation and translocation to distant neighborhoods.

Information Technologies would make easier the emergence of such networks since they allow for communications that once were limited by geography, proximity and serendipity. As the current Internet exemplifies, the adoption of open standards for internetworking provides many options of interaction and formation of aggregated structures we never had to consider before (i.e., business intranets and extranets, information portals, electronic marketplaces etc.). In the future Internet, humans will be helped in their actions by software agents, so human-agent and inter-agent transactions will become very frequent creating a potential for continuously emerging new behaviours and structures. Recent work in the area of Information Economies demonstrates that only the inclusion of large numbers of software agents as economic players gives rise to collective phenomena that are rare or even unknown in today's economies. Examples include: i) Spontaneous development of many specialised market niches in a population of competing information brokers, a pattern which is however "punctuated" by short periods of "undesirable" cyclical price wars for dominating the same narrow market [14, 15, 16]; ii) Emergence of vertically differentiated markets, less vulnerable to cyclical price wars, when they are populated by quality-sensitive (rather than price-sensitive) buyers [13].

5.2 Project's strength and innovation

This project has the ambition to advance the state-of-the-art in these areas by exploring emergent behaviours and networked structures in the (virtual) spatial organisation of the Information Society and Economy. The collective dynamics of a Society (and Economy) of co-evolving infohabitants is certain to be a new, fascinating, research area. Our approach, merging two different research directions, economic geography and modelling of the emergence of spatial structure in the real world, with recent work in the area Information Economies, constitutes the more innovative aspect of this project. In addition, we want to pursue these goals by combining analysis and emulation of emerging structures with concurrent development of a multiagent platform, enabling efficient large-scale experiments on Information Cities with very large numbers of infohabitants.

The particular experience of the partners involved in the project guarantees that these innovative aspects are not far fetched and can be realised within the proposed schedule. ARMINES – Ecole Polytechnique (ARMINES - X) has developed strong competencies in the fields of organisational economics and econometrics, and more recently in the areas of Internet Economics and Electronic Commerce [23, 24, 25, 26]. University of Crete has expertise and experience in the design and evaluation of resource allocation algorithms based on micro-economic principles as well as in transaction scheduling and routing algorithms that support the notion of performance goals [27, 28, 29, 30]. Swedish Institute of Computer Science (SICS) has acquired a long experience in software agents and developed agent-based systems and applications of agent technologies in different contexts [31, 32, 33, 34, 35, 36]. Foundation for Research and Technology (FORTH) has a strong expertise in the development of distributed software architectures [37, 38], in particular in defining Service Level Agreements in a distributed environment [39]. Institute for Advanced Commerce (IBM – IAC) is a leading worldwide research institution in the new area of Information Economies [13, 14, 15, 16]. They have sufficient experience in building complex simulation environments and mechanisms for

scalability and learning, which are essential for our information cities project. IBM - IAC and FORTH also have strong backgrounds in both distributed systems and on dynamics of information economies. IBM - IAC has built multi-agent systems for commerce and understands the design and implementation issues of multi-agent systems. They will use their expertise to work with SICS on ensuring a robust simulation environment. These partners have experience in modeling and understanding the behavior of multi-agent systems.

6 Community added value and contribution to EU policies

The proposed project will explore novel behavioral models, emulation techniques and multi-agent platforms to study the emergence of global virtual but stable aggregate structures we may call *Information Cities*, where people and organizations (product and service providers, intermediaries, consumer clubs, communities etc.) meet each other, co-operate and trade. In that way, the project will contribute to understanding fundamental issues related to the dynamics of the emerging Information Society, investing in particular the rise of *virtual* collective institutions. Information Cities as future collective institutions may, in fact, carry new forms of social and economic organization that have the potential to empower citizens as entrepreneurs and customers and affect the competitiveness of the European enterprises.

To address the question of emergence of new behaviors and structures for the Information Society, the project will combine experimental and theoretical research, bringing together interdisciplinary expertise in diverse fields, ranging from economics and organizational sciences to applied mathematics and software engineering and distributed system technologies. Apparently, this interdisciplinary approach would need complementary skills and resources that are only available in an Europe-wide basis, in different national organizations. Starting from this assumption, the project has been designed from collaboration within a high quality network of European researchers belonging to six different research groups (from both academia and industry), with high visibility and strong experience in their respective fields. The project consortium has the ambition to explore this opportunity in order to create new competencies, network coherence and European research excellence in the field of the organization of the emerging Information Society and Economy. The formal collaboration with *IBM Institute for Advanced Commerce,* a leading institution in these areas with a worldwide reputation, will give to the project rigor and strength while it concretely promotes scientific exchanges at an international level.

Moreover, the proposed project should provide a basis for the design and evaluation of alternative business models for electronic transactions in an Information Society and Economy, models that explicitly take into account the continuous emergence of patterns of aggregation and segregation. In addition, the project should contribute to the improvement of our understanding on what consumer protection may signify in the context of an Information Society, by providing a deep insight on the interactions and dependencies among autonomous and heterogeneous infohabitants, and the resulting composite structures. As a result, this work project may contribute to the evolution of current EU policies for the enterprise and the competition within the single market, in order to meet the complex requirements of the Information Society.

7 Contribution to Community social objectives

The iCities project addresses research questions related to the future of the emerging virtual world. At the same time, it has the ambition to offer exploitable results and valuable insights for the period of transition to a society and an economy where electronic transactions and network social communities should have a primordial role. Its contribution to Community social objectives consists of exploring and designing future environments within an Information Society, environments that may create new opportunities for work and allow for new services improving day-to-day life of the European citizens. In particular, research work on this area may provide models of the future (and anticipate needs) that can:

i) help businesses and individuals to take advantage of the new emerging environments over the Information Infrastructure and,

ii) give to collective organizations (as public administrations and social communities) opportunities to enhance efficiency and friendliness of their services.

8 Economic development and S&T prospects

8.1 Consortium strategies

The iCities project partners are keenly interested in applying the models, experimental results and emulation environment to be developed by the project in the development of real-world information cities, which are expected to thrive in large numbers over the Internet. Furthermore:

a. Research results relating to the formation, evolution, and stability of structures in an open (virtual) space with interacting autonomous agents, can be used as predictors to assist in the design of new electronic services. Guidelines and metrics for the evaluation of alternative models of interaction and their stability and evolution potential are expected to be essential for the competitiveness of European enterprises; especially for developing new application markets, related to the introduction of services to support agglomerations of autonomous business entities, with varying levels of commitment and time scales for cooperation -- ranging from short-term relationships focused on specific business tasks (as in the case of virtual enterprises) to more long-term relationships emphasizing sharing of resources and expertise (as in the case of on-line communities of peers with common interests). Such guidelines and metrics will also be required by policy makers in their task to regulate the rules of competition in electronic services, especially those involving on-line communities.

b. There is significant potential for the commercialization of results obtained from the study of models of autonomous agent behavior and their dynamics, as shown by current trends in the industry. There is, for example, a significant industrial interest in the development of Enterprise Portals as a strategy for connecting customers, business partners, suppliers and employees with the overall aim to improve efficiency and gain competitive advantage by facilitating the introduction of advanced, highly customizable services. This strategy recognizes that Web systems are not isolated corporate resources, but rather parts of an overall business approach, in the context of an economy that is becoming increasingly dependent on the Internet. The involvement of representatives of the research division of a major industrial partner (Institute for Advanced Commerce, IBM Research) is indicative of the potential for studies of this nature to have a significant commercial impact in the near future.

c. Dissemination of project results and interaction with both the academic and business communities will take place in a continuous basis. These activities will start immediately after the beginning of the project with the construction and maintenance of a Web site with specific support for collaboration, including a message exchange forum with facilities for archiving and full-text search, a collection of project-related documents (including public deliverables). [Note: This Web site will also enhance the communication among project partners, facilitating day-to-day issue management, scheduling of work assignments, and status tracking of deliverables.]. The aim of this initiative is to promote awareness of the project to the scientific community and to potential business users (portals, electronic marketplaces) and policy makers. Other specific actions for the dissemination of project results include: publications in scientific reviews and journals related to

the project's research topics and, potentially, the publication of a book and a CD-ROM containing documents, presentations, and visual material from simulations. Furthermore, two international workshops will be organized. The first will take place in US and be hosted by IBM Institute for Advanced Commerce (M8) and the second will be organized in Stockholm by SICS (M36). The objective of these Workshops is to interact with other scientists working on similar topics and receive feedback and suggestions for improvements and further research. They will also promote the visibility of the Consortium and, especially the second one, will help to the better exploitation of the project results. Additionally, iCities partners intend to participate in appropriate international workshops, conferences, and other events to present project results and experiences to the public, solicit feedback and encourage collaboration. More specifically, project partners intend to solicit the feedback, and possibly input, of research groups at major universities in the U.S., and in particular the MIT Sloan School of Management, the University of California at Berkeley, the Columbia University and the Santa-Fe Institute.

d. A final point, with special importance for European technological progress, is that the iCities project has the potential to serve as the seed for a European interdisciplinary network of excellence on the study and evolution of the emerging information society and economy. The partners believe that the formation of a sustainable on-line community of experts from the diverse fields of study addressed by the project will be a major achievement, providing the basis for a long-term commitment to the study and exploitation of the dynamics of interaction. The formation of such a community is considered essential for the successful and manageable large-scale deployment of advanced electronic commerce services. The iCities project specifically aims to contribute insight on organizational structures and their driving models of interaction, thus addressing a key prerequisite in understanding the "rules of encounter" that lead to the emergence of patterns of aggregation/segregation. These topics are expected to become increasingly important for the coming generations of global information infrastructures that will provide the basis of information economies.

8.2 Individual Strategies

In order to obtain good exploitation and dissemination results the individual partners will take their role in the Consortium as described in the following lines:

- **University of Crete (Computer Science Department)**

The University of Crete' participation in the project has the objective to give its researchers and students the opportunity to work on topics such as open distributed systems and information economies. It is also expected that the project will attract new researchers and graduate students interested in its topics of research. The results of the project research will be the basis for publications in referred international conferences and journals. Similar dissemination of results will take place through the development of web pages.

In its role as scientific and administrative coordinator for the project, the University of Crete will also make extensive use of Internet technologies for progress tracking and asynchronous collaboration for monitoring the development of deliverables and maintaining a calendar of events (such as meetings, milestones, reviews) in the project workplan.

- **FORTH (Institute of Computer Science)**

FORTH expects to enhance its expertise and know-how in the design and implementation of distributed software systems, and in the design of computer-mediated interaction and virtual spaces.

Specifically, the Parallel and Distributed Systems Division (PLEIADES), through its active participation in the design and implementation of the system platform for the iCities project, aims to apply and significantly extend its experience in the development of open distributed software systems. Moreover, the study of the dynamics of interaction that lead to aggregation/segregation patterns can provide the basis for further work, both research and applied, in the area of commerce intermediaries and enterprise portals.

The Assistive Technology and Human-Computer Interaction Laboratory (AT&HCI) aims to obtain detailed insights as to the design of novel virtualities which are likely to prevail in computer-mediated human activities, as a result of the techno-paradigm shift towards an information society. In the area of HCI design methodology, the project will provide the means to experiment with alternative developmental frames of reference (e.g. activity theory, distributed cognition, situated action, language/action perspective, etc) which can be used to guide the design of emerging computer-mediated virtual spaces (i.e., a virtual city).

All these benefits can be exploited by ICS-FORTH, which has developed cooperation with universities, research centers, and companies throughout Greece, Europe, and the world. ICS has adopted a strategy of promoting the commercial exploitation of R&D results by providing services (e.g. consulting), contracting with industrial partners for specific products, and participating in startup companies and joint ventures. ICS-FORTH is also a member of the European Research Consortium of Informatics and Mathematics (ERCIM), which has partners in 14 European countries. Most are independent Research and Development laboratories, with strong links to local industry. ERCIM partners have generated over 100 spin-off companies and do joint development with SMEs. ICS-FORTH can use its ERCIM partners to establish exploitation paths in those countries not directly covered by the project partners.

- **Swedish Institute of Computer Science (SICS)**

SICS has a proven record of disseminating its research results and promoting their commercial exploitation, through channels such as contract research, university and contracted education, scientific and non-scientific publications, standardization work, distribution and licensing of software, licensing of patents and other IPRs, spin-off companies, and not least human resource mobility.

In the iCities project, SICS will gain unique expertise in the simulation of very large communities of infohabitants and develop an experimental platform of wide applicability. These results will be of immediate value to the industrial collaborators of SICS, high-tech SMEs as well as leading computer and telecom companies, for exploring the large-scale effects of envisioned future services and products.

SICS will exploit the results in ongoing lines of research on electronic markets, Internet commerce, and agent-based system architectures. These involve a number of researchers and doctoral students to whom (preliminary and final) project results will be valuable research tools. In this context, the results will also be disseminated via an informal network of international research contacts.

SICS also plans to exploit the experience gained in iCities in the continuing development and refinement of Mozart. Large-scale experiments in iCities will benefit from extremely efficient concurrency and distribution mechanisms. Further improvements to Mozart stimulated by new challenges and insights in iCities will benefit a large and growing community of Mozart users and their applications.

SICS' research results with the highest applicability, usability, and commercial potential are expected to lead to the formation of spin-off companies. The documented record of the project's assessment of validity and usefulness of the results, and of the users' feedback will contribute to building trust towards such spin-offs. SICS will actively explore the possibility to exploit iCities results in spin-off form.

- **Ecole polytechnique (Laboratoire de l'Econometrie)**

The Laboratoire de l'Econometrie de l'Ecole polytechnique expects to enhance its expertise in the domains of formal behavioral models and the emergence of aggregated-level structures. The project provides also the opportunity to differentiate the experience of the Laboratory in new domains, related to the emerging Information Society. Other benefits from participation in the project include common work with computer scientists and engineers to create simulated environments for electronic transactions and relationships and international scientific exchanges. Publications, participation in scientific and business Conferences, seminars and other common academic activities should be the contribution of the Ecole polytechnique in the exploitation and dissemination of the results of the project.

- **IBM Institute for Advanced Commerce (IBM IAC)**

IBM IAC has an excellent reputation in the domain of electronic commerce, information economies, emergence of electronic marketplaces. They are a top quality research institute with well known track record in research and solutions for electronic commerce. This project may provide to Institute more insight in the economic and social processes that are shaping the future of the electronic marketplaces. It may also elaborate original ideas on the networks of interaction among infohabitants and the formation and evolution of aggregate structures in electronic marketplaces. IBM can leverage the

concepts from the project to consider fundamental principles for design and implementation of large scale virtual community centers, commerce trading sites and marketplaces.

- **Roles and Capabilities**

Workpackage	Partner	Key persons	Role
WP1	Ecole polytechnique (X – Econometrie)	Dr. Petros Kavassalis	Economics, behavioural science and management
WP2	IBM IAC	Dr. J. Sairamesh	Information Economies, economics and multi-agent system behavior
WP3	SICS	Dr. Sverker Janson	Multi-agent system design, implementation and experimentation
WP4	University of Crete	Prof. Christos Nikolaou	Experimentation and visualization and analysis

9 Workplan:

9.1 General description

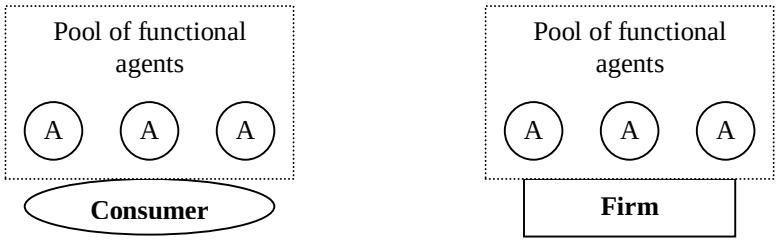
The Information Cities Project Work Plan consists of five Workpackages, spanning 36 months. The Workpackages are divided in Tasks. Deliverables will either be Reports or software prototypes. The purpose of defining a large number Deliverables is to sufficiently document the work process. Reports will serve as reference material and communicate into the scientific community and other audiences the results of the work. One of them (D2), called "Dynamic Report", will be continuously augmented while the project evolves, with the objective to serve later as the basis of a book on the emergence and evolution of Information Cities.

The Workpackages are scheduled to achieve the following partial objectives in this sequence:

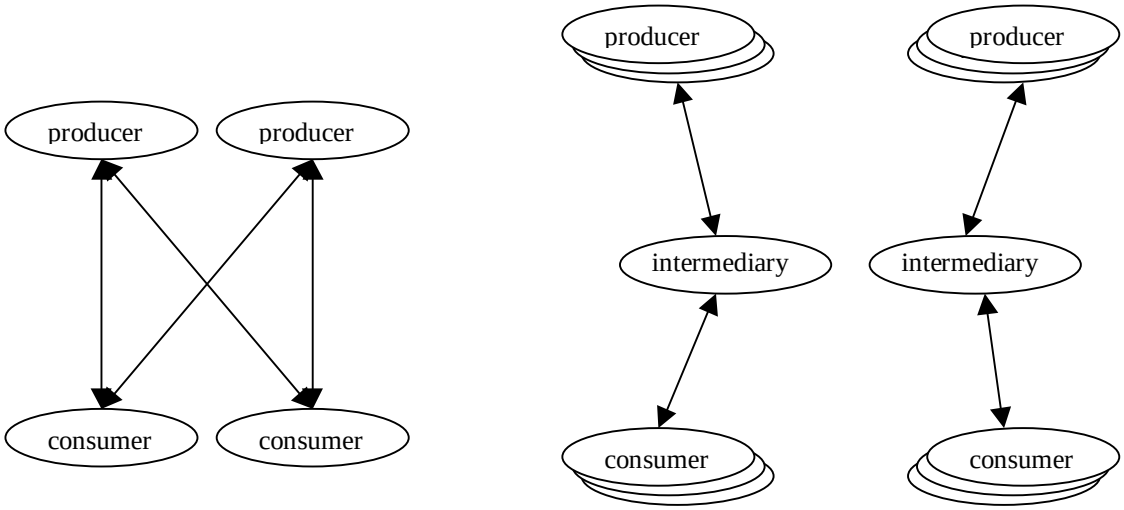
- Provide a deep theoretical background on the founding for the project scientific areas: i) complexity & self-organisation approaches (including application of these theories in studying the formation and evolution of real cities) and, ii) coalitions formation; produce, based on these theories, design principles for one or more formal models we develop in this project to capture aggregation/segregation patterns in a virtual world.
- Based on assumptions provided by the complexity approach, i.e., bounded rationality, learning, adaptation, distributed cognitive processes etc. [3, 4, 7, 8, 21], design behaviours and rules of interactions for infohabitants (i.e. individuals, virtual firms and software agents); then provide algorithms and models able to capture such behaviour patterns and "communication channels" between infohabitants.
- Design and implement a credible simulated software environment, a multiagent platform, which can serve to realise the algorithms and models previously designed. The platform will be based on Mozart [36], an advanced software development environment co-developed by SICS. Mozart targets modern multiagent and networked applications, with exceptional requirements on expressiveness and efficiency, offering a powerful combination of state-of-the-art constraint- and problem-solving capability, massively concurrent object-orientation, and transparent distribution over networked computing resources.
- Employ the multiagent platform to realise efficient large scale experiments on Information Cities with very large numbers of infohabitants; experiment with alternative model configurations in order to understand the dynamic emerging properties of Information Society and Economy (i.e. capture patterns of aggregation/segregation yielding large and complex, virtual, spatial structures, as Information Cities).

To achieve these objectives we will follow a global strategy consisting of three steps:

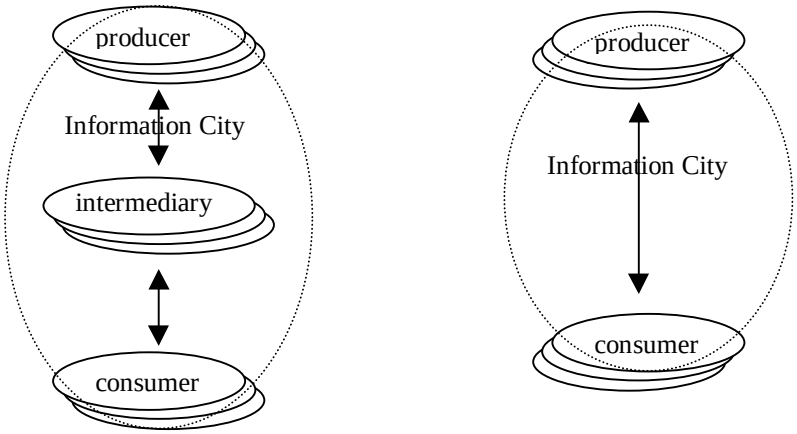
- In the beginning, we will design the "basic unit of action", a structure consisting of software representing individuals or firms (providers, intermediaries etc.) together with target-oriented software agents acting as "helpers" for humans



- Next, we will ask them to interact, first, directly and second, with the intervention of intermediaries helping to match buyers with sellers, and observe emerging structures



- Third, we will further experiment with aggregation/segregation trends, in order to leave more space for more complex structures of intermediation and virtual life, such as Information Cities, i.e. networks of many, different virtual, entities (providers, intermediaries, clubs of customers, banks, authorities, trust enforcers etc.)



9.1.1 General Approach

- **Top-down approach with feedback at various levels**

The approach is to model the Information City as a collection of infohabitants, interacting and participating in some form of social and commercial activities within the confines of the Information City. The decisions made by the inhabitants will be based on models from economics (utility function theory and evolutionary models) and behavioral science (learning and adaptation). Each infohabitant will make decisions based on rules derived from the above models. These rules will be defined over a space of variables in the Information City. The decision rules will vary from simple to complex (depending on the capability to learn and adapt to the changing conditions).

- **Diversity**

By employing various utility functions with varying degrees of randomness and uncertainty, we will be able to observe emergent behavior (within this space of variables). The approach, though top-down, will create a large enough space for variation and emergence of collective behavior.

- **Feedback**

Feedback will be applied at two levels in our approach: i) micro-level: we will use feedback of information for the infohabitants to adapt to the changes in environment of the information city; ii) macro-level: from our results and behavior we will be able to design better models and refine the decision rules and quantify the space of variables.

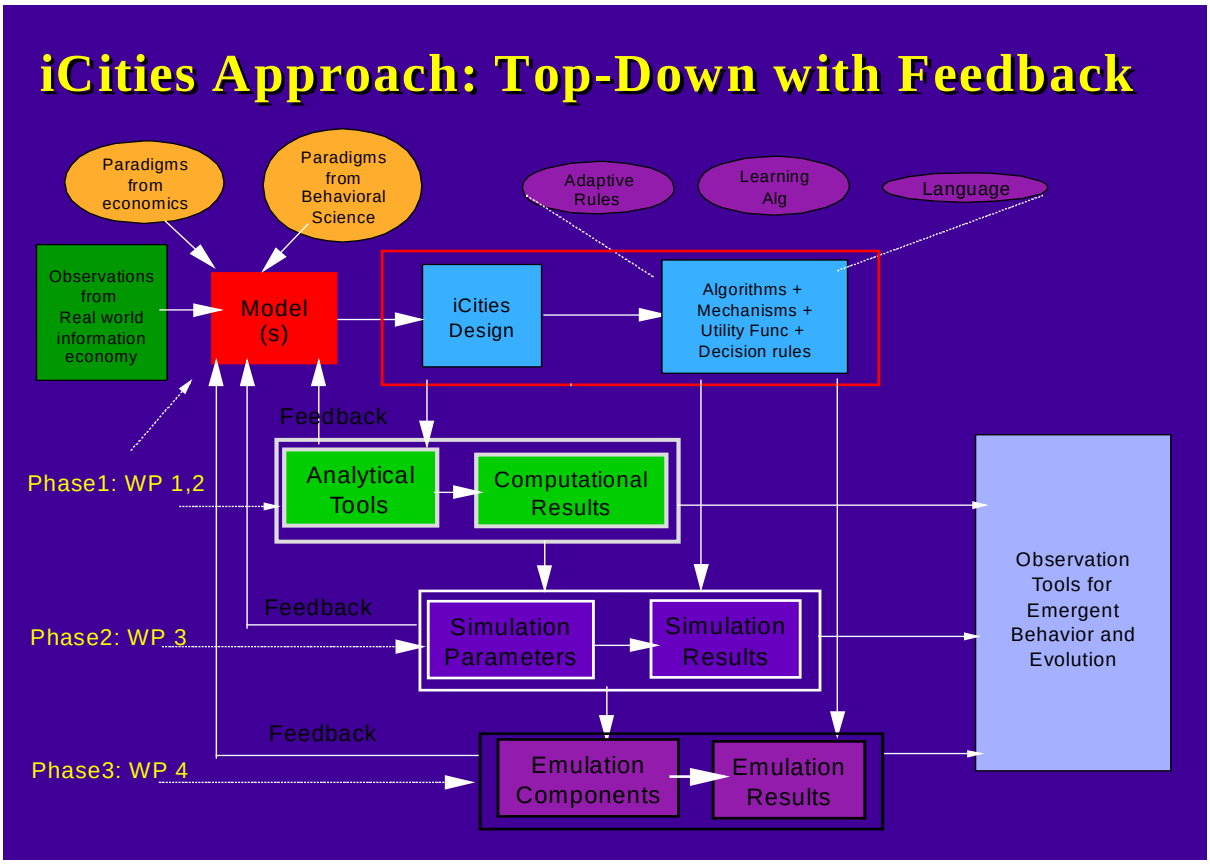
9.1.2 Outline

The approach is outlined below:

1. Design a model of an Information City (includes taxonomy of infohabitants, resources, services messages and protocols of interaction).
2. Design behavioral models of infohabitants in the Information City
3. Define the following: i) parameters of the Information City; ii) decision variables of the Information City; iii) the space of the various parameters and decision variables
4. Develop decision-making functions of the infohabitants using paradigms from economics (multi-attribute utility functions and/or very simple learning algorithms).
5. Apply principles from economics , behavioral science and coalition theories in order to develop decision rules for infohabitants. The rules will take into account multiple criteria and constraints of the infohabitants.

6. Diversify descision rules: Introduce randomness and uncertainity among the decision rules to create diversity among the infohabitants. Introduce extended learning capabilities into the decision rules for adaptability.
7. Simulate the Information City using the models and infohabitants.
8. Observe and analyze the behavior of the infohabitants and the information city. The behavior is captured by a set of parameters for each infohabitants. We observe the parameters over time. In addition, compare the various sets of decision rules of the various infohabitants. The goal is to observe trends of aggregation and segregation and collective behavior.
9. Compare and contrast various behavioral models and decision rule sets in order to analyze the behavior further and draw conclusions on the emergent behaviors.
10. Apply models and mechanisms to emulate a real Information City using a real testbed.
11. Apply the results to refine the model and decision rules (back to step 1).

The scheme below represents graphically this approach.



9.2 Workpackage list

The project is split into five Workpackages, four of which are technical and one of which is for project management.

Work-package No	Workpackage title	Lead contractor No	Person-months	Start month	End month	Phase	Deliverable No
WP 1	Theoretical Background and Project Principles for Modelling	4	21.9	M 1	M 8		D 1, D 2
WP 2	Interaction Networks – Design of Agents and Rules of Interaction	5	41.1	M 6	M 14		D 4, D 5
WP 3	Design and Implementation of a Multiagent Platform	3	120.1	M 4	M 30		D 3, D6 – D 11
WP 4	Experimentation with Alternative Model Configurations	1	90.6	M 19	M 36		D 12 – D 16
WP 5	Project Management	1	47.9	M 1	M 36		D 17 – D 19
	TOTAL		321.6				

Note: Workpackage managers

WP 1: Petros Kavassalis (affiliation: Partner 4, 1)

WP 2: Jakka Sairamesh (affiliation: Partner 5)

WP 3: Seif Haridi (affiliation: Partner 3)

WP 4: Christos Nikolaou (affiliation: Partner 1)

WP 5: Christos Nikolaou (affiliation: Partner 1)

9.3 Workpackage descriptions

9.3.1 Workpackage 1: Theoretical Background and Project Principles for Modelling

Workpackage number :	WP 1					
Start date or starting event:	M 1					
Participant number:	1	2	3	4	5	6
Person-months per participant:	7.4	3	1	4	0.5	6

Objectives

Survey the state-of-the art in the field of the self-organisation and coalition formation theories and develop, based on these theories, fundamental principles for one or more formal models to be able to capture patterns of organisation in a virtual world.

Description of work

Task 1.1: Complexity theory and self-organising systems: Survey
The work in this task will provide a comprehensive analytical framework of i) the different theoretical flavours under the common name "complexity approach" or "self-organisation" and, ii) coalition formation theories. These theories and the mathematical and computational techniques they have exploited, emphasise the discovery of the new structures (i.e. new "things", as complex entities stemming from aggregation or segregation) and the processes through which structure emerges across different levels of organisation [3, 4, 7, 8, 21]. In particular, the work will investigate the use of these theories to explain the emergence of spatial structure in the real world (i.e., location of economic activities, formation of cities and their evolution in time and space) and review existing models [8, 9, 10, 11, 12].

Task 1.2: Principles for a formal model capturing aggregation/segregation patterns in a virtual world
A possible first approach to the modelling could be based on a simple Information Society (and Economy) of producers, consumers, intermediaries and service providers of information goods and services. We will investigate the aggregation and segregation behaviours by capturing the fundamental factors in the model (such as search and transaction costs, proximity vectors, social benefit functions, contracts and others). In addition, we plan to understand the principles of the stable socio-economic structures for information cities to exist, where the infohabitants are deriving value. The novelty in this task lies in understanding and capturing the fundamental forces for aggregation and segregation in information societies.

Deliverables

D 1: Report with two parts: i) on self-organising systems with reference to the emergence of the spatial structure and, ii) on a formal model capturing aggregation/segregation patters in a virtual world.

D 2: "Dynamic" report starting with conclusions from D 1 (this report will follow the progress of the project and will be augmented with evidence provided by the next Workpackages).

Milestones and expected result

Overall, the main target achievement of this Workpackage consists of providing the necessary theoretical input and formal principles to design, in the subsequent Workpackages, credible models of interaction and successfully implement them.

Milestone 1: Defining and understanding the scope and boundaries of the project through detailed surveys and analysis of existing models (from economic geography, self-organization and collective action theories). A report on the survey and analyses will be provided (Deliverable D2). We will follow this up by a workshop.

9.3.2 Workpackage 2: Interaction Networks – Design of Agents and Rules of Interaction

Workpackage number :	WP 2					
Start date or starting event:	M 6					
Participant number:	1	2	3	4	5	6
Person-months per participant:	16.6	4	3	6	6.5	5

Objectives

1. Design the basic "unit of action". The "unit of action" is an infohabitant (which could be an individual, a firm, an organisation or a collection of software agents representing humans or organisations) which can perform its socio-economic actions within an Information Society.

2. Provide set of algorithms capturing infohabitant behaviours based on rules such as "bounded rationality" and learning (and continual adaptation) and design structures for interactions among infohabitants.

3. Apply the algorithms and rules to a society consisting of infohabitants trading not only information goods and services, but other goods and services as well, and following a set of community guidelines for coexistence (just like in Physical cities).

Description of work

Task 2.1: Design units of action
The work in this task consists of designing the different categories of basic units of action (i.e. complex entities including humans and software agents) for the following infohabitants: individuals, enterprise-providers, intermediaries and meta-mediaries.

Task 2.2: Design behaviours and provide algorithms
The work in this task is twofold:

- Define cognitive models of behaviour for the infohabitants (humans, virtual firms, and software agents) designed in the above Task. Input from WP 1 will be used to elaborate such behavioural rules. Humans (individuals and firms) will be considered with limited cognitive resources ("bounded rationality"), an assumption which makes them develop "interpretative skills" to understand the external world (rather than being rational optimisers). Software agents will be target oriented, with targets initially defined by humans, but self-motivated too, i.e., possessing a capacity of learning and adaptation and, in consequence, of discovery of "new things", including opportunities of interaction.
- Formalise the above behaviours in terms of a procedure (set of algorithms describing rules)

Task 2.3: Structure interactions
In the theoretical approach formulated in WP 1/Task 1.1, economic and social action involves interaction among agents. Emerging phenomena are both constrained and carried by networks defined by recurring patterns of interaction. In this Task we will describe structures, which may carry later, during the implementation phases, interactions among agents. These structures may be "communication channels" such as, affiliation contracts including authorisations and access rights, reciprocal engagements, clubs of customers linked to an intermediary etc.

Task 2.4: Case study
Development of a case study involving the following infohabitants: buyers, sellers, resellers, brokers and retailers. These infohabitants are producing, trading, and consuming information goods and services, and sharing some common basic community services for interactions amongst themselves. This case study will provide the necessary input for WP 3, where a multiagent system will be developed to provide a simulation/emulation environment to observe, investigate and analyse the behaviours of the infohabitants.

Deliverables

D 4: Report on designing: i) basic "units of action" (producers, consumers, intermediaries), ii) behavioural models for them, iii) methods to formalise these models and, iv) interaction rules for infohabitants in an emerging Information Economy and Society (combined report of Tasks 2.2 and 2.3). Added to D 2.

D 5: Report on case study involving infohabitants living within an Information Economy. Added to D 2.

Milestones and expected result

The WP 2 will establish behavioural models and provide algorithms, which will be implemented next in a software agent environment (WPs 3 and 4). It will also design structures to carry interactions among agents.

Milestone 2: Design of the models for information cities using paradigms from economics and behavioural sciences. Design of "units of action", decision rules and variables, information structures and interaction mechanisms. A report capturing these will be provided (Deliverable D4).

9.3.3 Workpackage 3: Design and Implementation of a Multiagent Platform

Workpackage number :	WP 3					
Start date or starting event:	M 4					
Participant number:	1	2	3	4	5	6
Person-months per participant:	7	61.7	47	1.2	2	1.2

Objectives

Design a system that can serve to realise the algorithms and models defined in WP 2, for the purposes of experimenting with these models and observing patterns of aggregation/segregation. Specifically implement:

1. A run-time environment for software components that represent the basic units of action. For this environment, we will use an architecture that has been developed by SICS [35].
2. A framework for programming the behavioural rules governing the system modules. The programming environment for the infohabitants will be based on a distributed software architecture *Mozart* developed by SICS [36]. Within this framework, our objective is to study various models of infohabitants.
3. Services for supporting the discovery of interaction opportunities, and engagement in interactions under terms specified by contracts among the various infohabitants.

Description of work

Task 3.1: Design and implement the infrastructure
Design and implement the basic infrastructure for representing units of interactions as collections of agents, with support for adaptation (introduction/removal of agents and services, and dynamic changes of entities' behaviour). An important requirement on the platform is that it will be able to run on the order of 100 thousand agents. This will use the lightweight threads of *Mozart* and the ability of *Mozart* applications to be spawned on workstation farms. The platform will make agents easy to inspect. We will develop basic management tools for experimentation to be able start/stop and snapshot the state of the simulation and resume at any time. We will also be able to run experiments by using either simulation or real-time clock, without changing the code of simulation/emulation experiments.This Task will be organised according to the principle of iterative design/development which allows for evaluation feedback (e.g.: changes in requirements, request for additional functionality, as well as standard software maintenance) to be an integral part of the development process. In this task , following will comprise a bulk portion of the work

1. Information structures and schema to define the information city and infohabitants.
2. Support components such as bulletin boards, messages structures, banks and others (this will be adding to more components to what *Mozart* has).
3. Graphical tools for viewing the results of the simulation or state during the simulation. This has to be customized to the information city and the parameters we define.

Task 3.2: Design and implement behavioural language and interaction mechanisms
Design and implement a customised higher-level language for behavioural descriptions of agents. This will use the built-in facility of *Mozart* to extend the Oz language with customised syntax.
Design and implement of a set of basic algorithms and mechanisms for various models/protocols of interaction and communication among infohabitants. In addition, we will have a simple rule language, which can be expressed in terms of the parameters of the information city, and this language will be used to design decision rules for infohabitants. These include request-reply communication, multicast communication, event/service subscriptions, discovery and notification, contact-net, and auction protocols for trading. These interaction protocols are intended to be a library used in the various simulation/emulation experiments.

This workpackage will be evolving based on the models that we develop for the information city. New components will need to be added to *Mozart* if needed.

Deliverables

D 3: First demonstration of multiagent platform on top of Mozart.

D 6: Design document describing the architecture of the multiagent system platform. Added to D 2.

D 7: Prototype implementation of the simulation environment (initial version).

D 8: Developer's guide for the construction of units of action with programmable behaviour. Added to D 2 as appendix.

D 9: Implementation manual of the interaction/communication channels. Added to D 2 as appendix.

D 10: Prototype implementation of the simulation environment (intermediary version incorporating feedback from Task 4.3).

D 11: Prototype implementation of the simulation environment (final version).

Milestones and expected result

WP 3 will provide an infrastructure for experimentation with alternative model configurations in WP 4.

Milestone 3: An implementation of a multi-agent platform ready for simulation of an information city (including the language for expressing the behaviour of infohabitants). In addition we will support a library of interaction protocols (Deliverables D6, D8, and D9)

9.3.4 Workpackage 4: Experimentation with Alternative Model Configurations

Workpackage number :	WP 4					
Start date or starting event:	M 19					
Participant number:	1	2	3	4	5	6
Person-months per participant:	34	26.6	9	9	2	10

Objectives

With this Work Package, the project enters its final stage: emulate the models defined in WP 2 using the multiagent system built in WP 3. Work in this work package will take place in four stages:

1. Numerical and simulation results for the various models of infohabitants. Consider two families of agents, consumers (i.e., individuals) and producers (providers of goods). Our goal is to observe patterns of interaction and stability within a society of infohabitants.
2. Introduce a third family of agents, intermediaries, within this society of infohabitants and observe modification of trends previously obtained.
3. Observe emergence and stability of Information Cities, where congregations of infohabitants find stability in their activities. Analyse using simulations the formation of information cities. Observe patterns of aggregation and segregation in this society of infohabitants and intermediaries.
4. Introduce various competing Information Cities, and analyse, via simulations, the behaviour of infohabitants and the “competitive advantage” of information cities.

Description of work

Task 4.1: Monitoring Tool
Development of an interactive software module, which will employ selected visualisation techniques for representing interactions between infohabitants, as well as for locating and "highlighting" emergent structures.

Task 4.2: Realisation of software entities
Realisation of software entities with the behavioural parameters prescribed by the models of WP 2.

Task 4.3: Experimentation
Experimentation with, and evaluation of, alternative scenarios (with and without intermediaries).

Task 4.4: Emerging structures
Advanced results – Observation of patterns of aggregation/segregation and emerging structures.

Task 4.5: Case study: emulation of computation and information markets
Use the platform to emulate the model defined in the case study developed in Task 2.4.

Deliverables

D 12: Monitoring tool to visualise interactions and highlighting emerging structures.

D 13: Implementations of representative consumers, producers and intermediaries. Added to D 2 as appendix.

D 14: Report on the results obtained during the two stages of experimentation. Added to D 2.

D 15: Report on experiments and conclusions from the emulation of the case study developed in D 5. Added to D 2.

D 16: Final report on the formation, evolution and stability of Information Cities (evolution of D 2, it will include: D2, D4, D5, D6, D8, D9, D13, D14, D15). This Report will also include input from the Workshop regarding project outcome and recommendations on the application of alternative patterns of organisation in realistic business environments.

Milestones and expected result

We expect this Workpackage to capture patterns of aggregation and enhance our understanding of the role of intermediaries in Information Economies, providing conclusions and evaluation of scenarios for the future of the emerging Information Infrastructure.

Milestone 4: A prototype implementation of infohabitants along with the understanding gained by the experimentation with alternative scenarios of evolution. Furthermore we will employ these software entities and experience within an emulated information city (Deliverable D11, D12, D13, D14, and D15).

Milestone 5: Observation and analyses of the emergent behaviour from the advanced simulation results such as aggregation/segregation patterns, interactive behaviours and emerging structures. A workshop will be held to evaluate the outcome of the project (Deliverable D16).

9.3.5 Workpackage 5: Project Management

Workpackage number :	WP 5					
Start date or starting event:	M 1					
Participant number:	1	2	3	4	5	6
Person-months per participant:	38.5	0	6.3	1.4	1	0.6

Objectives

1. Manage the project on administrative and technical level
2. Co-ordinate the contacts with the EC
3. To control quality and timing of project results and to resolve conflicts
4. Assure good dissemination and exploitation of results
5. Manage the assessment-evaluation process

Description of work

Task 5.1: Project management

- Carry out the overall project management, including administrative management
- Define the project standards and guidelines in relation to deliverables, presentations, information and communication flow
- Organise official project meetings and reviews
- Co-ordinate, compile and distribute project reports

Task 5.2: Workpackage management

- Carry out the technical project management
- Co-ordinate the developments in the different Workpackages
- Ensure system integration and resolve technical conflicts

Task 5.3: Dissemination-exploitation

- Create and maintain a web page with presentations, project reports, publications and related material informing scientific communities and business people on the project progress
- Explore potential applications of the project results in e-markets and e-business

Task 5.4: Assessment-Evaluation

- Provide in time input to the management on the evolution of the project
- Provide final evaluation on the results obtained by the project

Deliverables

D 17: Report on Dissemination-Exploitation and Assessment-Evaluation (first edition, month 12)

D 18: Report on Dissemination-Exploitation and Assessment-Evaluation (second edition, month 24)

D 19: Report on Dissemination-Exploitation and Assessment-Evaluation (final edition, month 36)

9.4 Deliverables list

Deliverables list

Del. no.	Del. Name	WP no.	Lead participant	Estimate person-months	Del. type	Security*	Delivery (proj. month)
D 1	Report with two parts: i) on self-organising systems with reference to the emergence of the spatial structure and, ii) on a formal model capturing aggregation/segregation patters in a virtual world.	**1**	**4**		**R**	**PU**	**8**
D 2	"Dynamic" report starting with conclusions from D 1 (this report will follow the progress of the project and will be augmented with evidence provided by the next Workpackages)	**1**	**1**		**R**	**PU**	**8**
D 3	First demonstration of multiagent platform on top of Mozart.	**3**	**3**		**P**	**PU**	**12**
D 4	Report on designing: i) basic "units of action" (producers, consumers, intermediaries), ii) behavioural models for them, iii) methods to formalise these models and, iv) interaction rules for infohabitants in an emerging Information Economy and Society (combined report of Tasks 2.2 and 2.3). Added to D 2.	**2**	**2**		**R**	**PU**	**13**
D 5	Report on case study involving infohabitants living within an Information Economy. Added to D 2.	**2**	**5**		**R**	**PU**	**14**
D 6	Design document describing the architecture of the multiagent system platform. Added to D 2.	**3**	**3**		**R**	**PU**	**15**
D 7	Prototype implementation of the simulation environment (initial version).	**3**	**3**		**P**	**PU**	**18**
D 8	Developer's guide for the construction of units of action with programmable behaviour. Added to D 2 as appendix.	**3**	**3**		**R**	**PU**	**19**
D 9	Implementation manual of the interaction/communication channels. Added to D 2 as appendix.	**3**	**3**		**R**	**RE**	**22**
D 10	Prototype implementation of the simulation environment (intermediary version incorporating feedback from Task 4.3).	**3**	**3**		**P**	**PU**	**24**

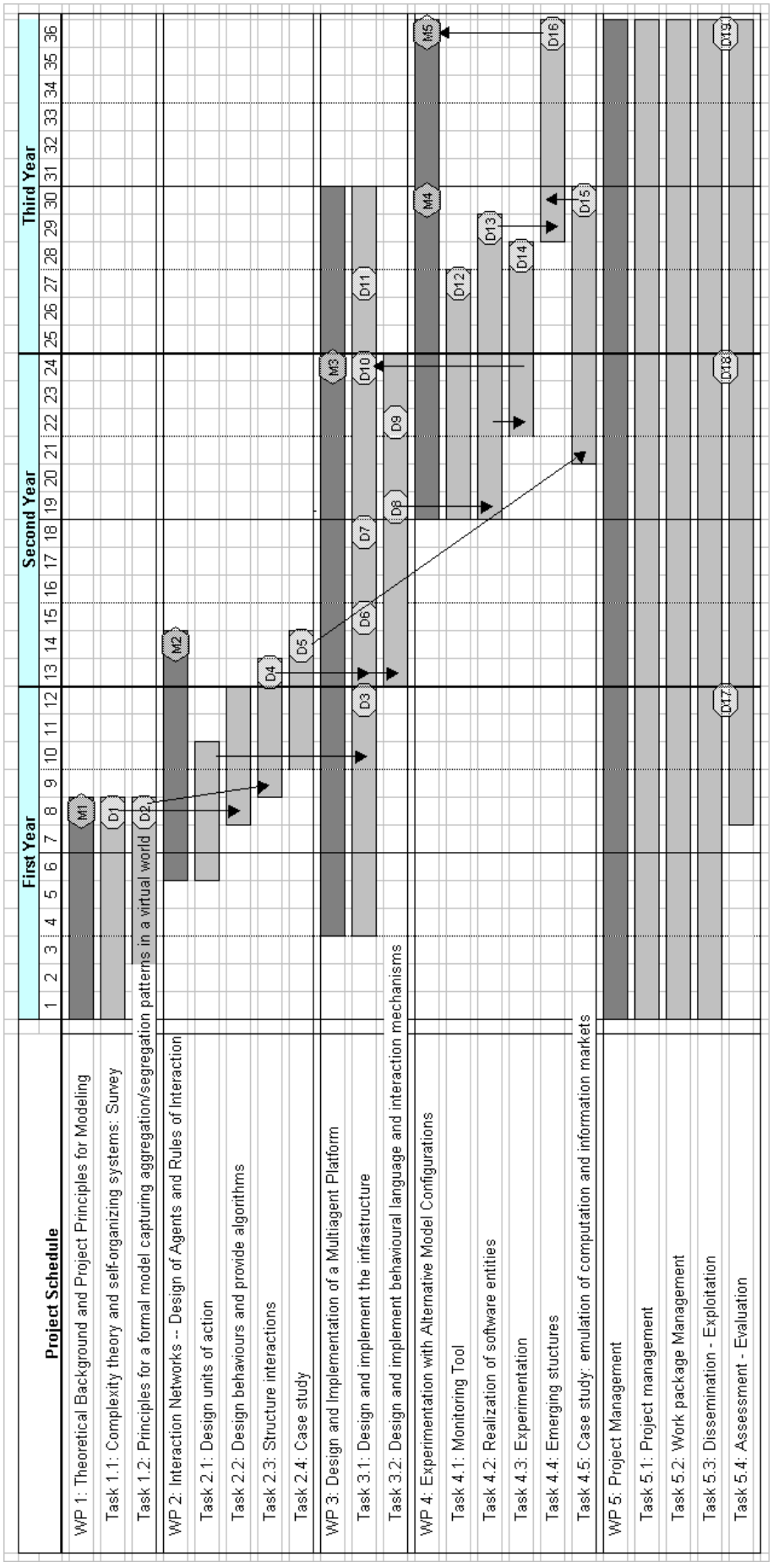
D 11	Prototype implementation of the simulation environment (final version).	**3**	**3**		**P**	**PU**	**27**
D 12	Monitoring tool to visualise interactions and highlighting emerging structures	**4**	**2**		**P**	**PU**	**27**
D 13	Implementations of representative consumers, producers and intermediaries. Added to D 2 as appendix.	**4**	**2**		**R, P**	**PU**	**29**
D 14	Report on the results obtained during the two stages of experimentation. Added to D 2.	**4**	**1**		**R**	**PU**	**28**
D 15	Report on experiments and conclusions from the emulation of the case study developed in D 5. Added to D 2.	**4**	**2**		**R**	**PU**	**30**
D 16	Final report on the formation, evolution and stability of Information Cities (evolution of D 2, it will include: D2, D4, D5, D6, D8, D9, D13, D14, D15). This Report will also include input from the Workshop regarding project outcome and recommendations on the application of alternative patterns of organisation in realistic business environments.	**4**	**1**		**R**	**PU**	**36**
D 17	Report on Dissemination-Exploitation and Assessment-Evaluation (first edition)	**5**	**1**		**R**	**PP**	**12**
D 18	Report on Dissemination-Exploitation and Assessment-Evaluation (second edition)	**5**	**1**		**R**	**PP**	**24**
D 19	Report on Dissemination-Exploitation and Assessment-Evaluation (final edition)	**5**	**1**		**R**	**PP**	**36**

9.4.1 Milestones

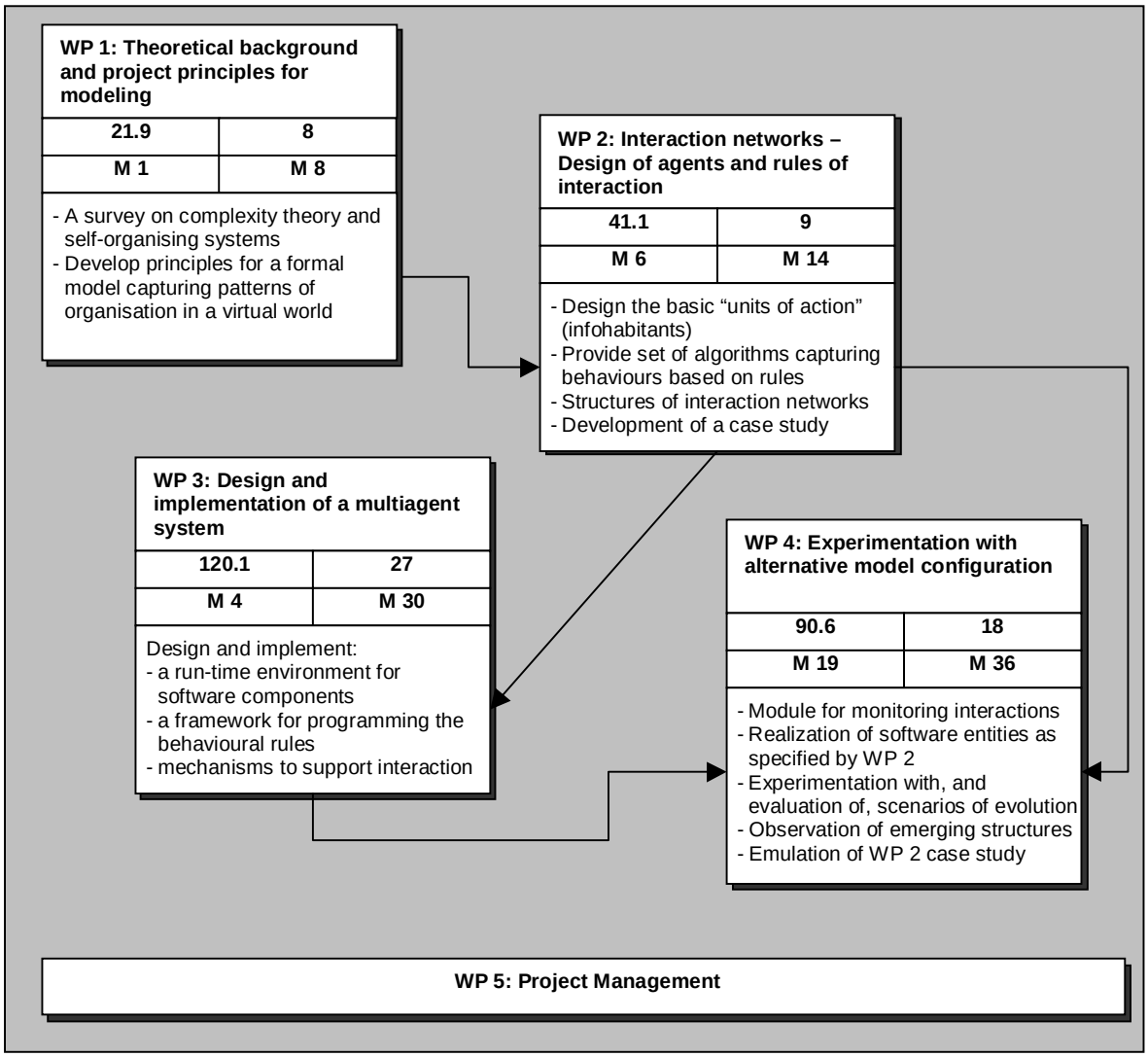
Milestones

Milestone no.	Milestone Description	WP no.	Delivery (proj. month)
M 1	Defining and understanding the scope and boundaries of the project through detailed surveys and analysis of existing models (from economic geography, self-organization and collective action theories). A report on the survey and analyses will be provided (Deliverable D2). We will follow this up by a workshop.	**1**	**8**
M 2	Design of the models for information cities using paradigms from economics and behavioural sciences. Design of "units of action", decision rules and variables, information structures and interaction mechanisms. A report capturing these will be provided (Deliverable D4).	**2**	**14**
M 3	An implementation of a multi-agent platform ready for simulation of an information city (including the language for expressing the behaviour of infohabitants). In addition we will support a library of interaction protocols (Deliverables D6, D8, and D9)	**3**	**24**
M 4	A prototype implementation of infohabitants along with the understanding gained by the experimentation with alternative scenarios of evolution. Furthermore we will employ these software entities and experience within an emulated information city (Deliverable D11, D12, D13, D14, and D15).	**4**	**30**
M 5	Observation and analyses of the emergent behaviour from the advanced simulation results such as aggregation/segregation patterns, interactive behaviours and emerging structures. A workshop will be held to evaluate the outcome of the project (Deliverable D16).	**4**	**36**

9.5 Project planning and timetable



9.6 Graphical presentation of project components



Workpackage Title	
Total man/months	**Duration (months)**
Starting month	**Ending month**
Short description of tasks	

Graphical notation for Workpackage descriptions

9.7 Project management

9.7.1 Management Capability of the Co-ordinator

Co-ordinator: University of Crete (Department of Computer Sciences) will be the co-ordinator of the *Information Cities* project and will have the responsibility for the overall project management. The *Information Cities* project is of high scientific importance for the University of Crete and all needed resources will be available.

Project Manager: Professor Christos Nikolaou will be assigned the task of the Project Manager (PM). He has long year experience in managing projects at the University of Crete and FORTH where he has proved his sound management capabilities. He has also gained experience in successfully managing European R&D projects. Adding to that, he is an excellent expert in the area of Information Technologies, in particular in the area of open distributed systems and applications, databases and online transaction processing systems, digital libraries, Information Economies and electronic commerce, and Performance Management. This ensures the project management as powerful both in the area of management and content.

Assistant Project Manager: Dr Petros Kavassalis from Ecole polytechnique (now in University of Crete), with solid background in economics and organizational sciences and experience from participating in the MIT Internet Telecommunications Convergence Consortium (MIT ITC), will essentially help Professor Nikolaou (as Assistant Project Manager, aPM) in managing the project and pushing the research work to challenging scientific results.

Roles: The Project Manager (PM) is fully responsible vis-a-vis the Commission for any activity related to the management of the project (negotiations, cost statements and timetables, submission of deliverables, progress and management reports and of the summary of the technological implementation plan, monitoring of Commission payments to parties, etc.). The PM may delegate on the aPM the tasks for the internal management of the project. He may replace PM in all internal meetings which do not require the physical presence of the PM.

9.7.2 Organization and Management structure

The project management has to handle the different needs and requirements of the partners. The project management structure implies both central and local project control. The project will be managed by a Project Board:

The *Project Board* (or Steering Committee) consists of:

- The Project Manager and the assistant Project Manager
- The Work Package Managers (WP 1: P. Kavassalis; WP 2: J. Sairamesh; WP 3: S. Haridi; WP 4: Ch. Nikolaou).
- C. Stefanidis from FORTH and S. Janson from SICS

The Project Board (PB) has the overall responsibility in relation to the Commission. The PB meets frequently (approx. every 6 months). It is chaired by the PM or the aPM (when PM is not present). The main tasks of the PB are to approve the appointment and withdrawal of the project, decide on scientific issues (redefinition of tasks, quality control, etc.), review the project results internally with regard to deliverables and milestones, decide on changes in partner participation and allocation of resources among the partners, etc.

The Project Manager (PM) and the Assistant Project Manager (aPM) prepare and organize the Project Board meetings, i.e. present project status and progress, propose necessary corrective actions in order to meet milestones and assure high scientific quality.

The PM and his Assistant also carry out the technical project management, i.e. assuring consistency between the various Work Packages, maintenance of the project schedule, etc. They are thereby responsible for the Work Package control of the project. The Work Package Managers ensure the successful completion of a specific Work Package i.e. each Workpackage Manager is responsible for the achievement of specific goals and performs thereby a functional control of the project, co-ordinating all the involved activities in order to obtain the goal. For each task within a work package a responsible partner is appointed to ensure the task progress, goals, resources, etc., i.e. the WPM and the task responsible partners constitute the management of the work package. In order to ease the task management, in most cases, a deliverable presents the results of each task.

In addition, the PM an the aPM carry out the administrative project management, e.g. updating of records of costs, resources and time, The project activities are managed locally at each partner by a main contact person who supervises all project activities within his organization, collects requested information etc.

All conflicts will be resolved as locally as possible (i.e. within the Workpackages forces). At the last resort, the Project Co-ordinator will call for an exceptional meeting of the Project Board Within the meeting, agreements should be searched for through dialogue and mutual concession between the partners as it is the practice within the scientific community. In the case that a negotiated solution is not possible, the Project Board will take decisions by vote. In the extreme cases where for any reason a conflict cannot be resolved, or if a partner wants to withdraw from the Consortium, the Commission will be duly informed.

9.7.3 Mechanisms for assessment-evaluation

The Project Board is responsible for the assessment and evaluation of both, project progress and final results. Specific meetings of this Board for evaluation of the obtained results will be organized at the milestones of the project. In addition, a board of external evaluators (members of the scientific community and, eventually, representatives from the world of e-business) will be associated with the Project Board to evaluate in M18 and M32 the results and the future perspectives of the project.

9.7.4 The Project File

The Project File will contain all documents related to the management and progress of the project and in particular: i) correspondence with the EC, ii) minutes of all meetings of the Project Management Board, iii) Reports (especially the Dynamic Report – Deliverables D2 and D13), iv) documentation for the software produced by the project.

9.7.5 On-line tools

Project management will be facilitated by Internet/Web technologies for communication among participants: public WWW server, mailing list with support for archiving, message threads and full-text search, public and restricted access forums, progress tracking tools for monitoring the development of deliverables, calendar of events (meetings, milestones, reviews). These tools will also provide channels for dissemination of results.

10 Clustering

Interactions with three UIE projects (ALFEBITE, DIET, DREAM) will be realized through participation in common meetings.

11 Other contractual conditions

1. Partner no. 1, UoC, will allocate 4,000 Euros per year for travels in US (attending Workshops, Conferences and visiting Research Groups working in similar to the Project subjects in US Universities).
2. Partner no. 2, FORTH, will take in charge travel expenses for Dr. Jakka Sairamesh from IBM (three trips per year from US to Europe), evaluated in 3,500 Euros per year (cost category: Other Project Costs, see CPF forms).
3. Partner no. 3, SICS, will allocate 10,000 Euros during third year in the organization of a Workshop (M36).
4. Partner no. 3, SICS, will allocate 3,500 per year for travels in US (attending Workshops, Conferences and visiting Research Groups working in similar to the Project subjects in US Universities).
5. The Project will organize two international workshops. The first will take place in US (New York State) and be hosted by IBM Institute for Advanced Commerce (M8). Consortium partners will cover travel and leaving expenses for its researchers participating in this Workshop, from their respective travel budgets. The second Workshop will be organized in Stockholm by SICS (M36). A specific budget of 10,000 Euros has been allocated in this regard [Note: The objective of these Workshops is to interact with other scientists working on similar topics and receive feedback and suggestions for improvements and further research. They will also promote the visibility of the Consortium and, especially the second one, will help to the better exploitation of the project results].

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Appendix A – Consortium Description

A.1: Description of the Consortium

The Consortium comprises six Partners, from both academia and businesses.

- University of Crete (Computer Science Department) is Partner No 1 and Co-ordinator of the project.

The other participants are:

- Partner No 2: FORTH (Institute of Computer Science)
- Partner No 3: Swedish Institute of Computer Science (SICS)
- Partner No 4: Ecole Polytechnique (Laboratoire de l'Econometrie)
- Partner No 5: IBM T. J. Watson (Institute of Advanced Commerce)

The interdisciplinary nature of the project (i.e. study patterns of aggregation/segregation in the Information Society and explore the emergence of collective forms of organization as Information Cities, while using a multi-agent environment to do experiments), has required the constitution of a network of partners with very complementary expertise. In fact, the Consortium for the proposed project includes participants with such complementary skills and considerable experience in their respective fields. Researchers specialized in economics and organizational sciences will work together with computer scientists and engineers to: i) create a credible software multi-agent environment for experimentation and, ii) draw conclusions on emerging behaviors and structures (as Information Cities) within the Information Society on the basis of the above experimentation. Moreover, the participation of IBM Research (Institute of Advanced Commerce and IBM Zurich Laboratory) should give to this work a solid feedback from the industry and provide incentives to scientific excellence.

In order to realize the objectives of the project, the individual partners will contribute with their expertise as described in the following lines:

- The ***University of Crete (Computer Science Department - CSD/UoC)*** will design and implement algorithms and mechanisms for various models of interaction between infohabitants allowing to realize formal relationships (i.e., commitments and dependencies) among infohabitants. Furthermore, it will contribute to the development of mechanisms for facilitating the discovery of interaction opportunities in the shared interaction space provided by the iCities run-time environment. It will also coordinate and actively participate in the experimental evaluation of alternative models of behavior for infohabitants, aiming to gain insight on the dynamics of aggregation/segregation patterns.
- ***FORTH (Institute of Computer Science)*** will contribute to the project by developing a framework for programming the behavior of autonomous agents that represent "infohabitants" (consumers, firms, intermediaries). This framework includes a formal language for expressing the capabilities (supported actions) and interests (intentions/goals) of infohabitants -and-the requirements on trust and other service-level qualities. The framework will include an interpreter for sequencing the execution of actions on behalf of agents (implementation of interaction sequences) and explicit support for humans to override the automatic (pre-programmed) behavior of agents, as well as

support for on-line monitoring of interactions through a logging facility. Moreover, it will select and implement specific visualization techniques (building upon existing visualization work, such as hyperbolic visualisation [publication 40], flip zooming [publication 41], spiral calendars [publication 42], etc., as well as devising real-world analogies to enhance intuition) into a module that will be used for monitoring (and representing the dynamic nature of) interactions between infohabitants, as well as for locating and "highlighting" emergent structures (complex intermediaries, metamediaries, information cities, etc.).

- The ***Swedish Institute of Computer Science (SICS)*** will take the main responsibility for the development of a software platform enabling efficient large scale experiments on Information Cities with very large numbers of infohabitants. The platform will be based on Mozart, an advanced software development environment co-developed by SICS. Mozart targets modern multi-agent and networked applications, with exceptional requirements on expressiveness and efficiency, offering a powerful combination of state-of-the-art constraint- and problem-solving capability, massively concurrent object-orientation, and transparent distribution over networked computing resources. The Intelligent Systems Laboratory of SICS is well known for its ability to combine scientific excellence with the development of advanced software systems, which are widely used in the scientific community.
- The ***Laboratoire de l'Econometrie de l'Ecole polytechnique*** will mostly contribute in the design of behavioral models for infohabitants and the elaboration of formal models for capturing patterns of aggregation/segregation in a virtual world. It will also work to capture "appreciative" and "formal" analogies between existing models investigating emergence of cities and agglomerations in the real world and our new models applying to a virtual world. The solid reputation of this Laboratory in the fields of micro-economics and organizational sciences, and its particular expertise in developing mathematical and computational methods for economic analysis, provides the necessary guarantees for scientific excellence.
- The ***IBM Institute for Advanced Commerce (IAC)*** is a part of IBM T. J. Watson Research Center, Yorktown Heights, NY, 10598. This institute's theme is advanced research and development in E-commerce and economics of the Internet and Information. The research from this institute will provide many insights into various aspects of the project from its unique experience in developing simulations and prototypes for information economies. Their prior and current work on Information Economies and economics of E-commerce will be a very valuable in capturing the right set of models for understanding the behaviour of Information Cities. IBM Institute of Advanced Commerce's contribution will also contribute to design algorithms capturing behaviors of infohabitants and evaluating results from experimentation.

We note in this occasion, that in the final stage of this project, which consists of experimenting with alternative model configurations to obtain emergent structures, *all* partners will participate in close collaboration.

A.2: Description of the Participants

A.2.1: Partner No. 1 (Coordinator): University of Crete (Computer Science Department)

The Computer Science Department of the University of Crete (CSD/UoC) was established in 1984, as the second Computer Science/Engineering department in Greece. Its research activities include information systems, software engineering, parallel architectures and distributed systems, computer vision and robotics, digital communications, network management, machine learning, decision support systems, formal methods in concurrent systems, computer architectures and VLSI design, computer aided design, medical informatics, human-computer interaction, and rehabilitation tele-informatics. CSD/UoC collaborates closely with the Institute of Computer Science of the Foundation for Research and Technology - Hellas (FORTH), mainly to pursue R&D activities via participation in European programmes such as ESPRIT, RACE, ACTS, and to strengthen contacts and knowledge transfer with industry.

The key personnel to be involved in the proposed project will be Professor Christos Nikolaou and Associate Professor Catherine Houstis.

Professor Christos Nikolaou is Professor of Computer Science and Vice-Rector at the University of Crete in Greece. He has been Chair of the Executive Committee of the multinational European Research Consortium for Informatics and Mathematics (ERCIM, 1995-98). He was one of the leading early researchers who applied microeconomic algorithms for load balancing, resource allocation and data replication in computer systems and networks. In addition, he worked on on-the-fly dynamic goal-oriented transaction routing algorithms that were applied in commercial transaction monitors. He has been Chair of the 2nd European Conference on Digital Libraries, September 1998, Crete, Greece (http://www.csi.forth.gr/2EuroDL). He received Ph.D. and M.Sc. degrees in Applied Mathematics (Computer Science) from Harvard University in 1982 and 1979, and a Diploma in Electrical Engineering from the National Technical University, Athens, Greece, in 1977. Before joining the University of Crete in 1992, he was a Research Staff Manager at the IBM T. J. Watson Research Center, NY, where he worked since 1982. For his contributions he received the IBM Outstanding Innovation Award and the IBM Invention Achievement Award. His areas of expertise and major technical contributions are: Distributed Systems and Applications, Databases and Online Transaction Processing Systems, Digital Libraries, Information Economy and Electronic Commerce, and Performance Management.

Professor Catherine Houstis received Ph.D. and M.Sc. degrees in Computer Science from Purdue University, in 1973 and 1977 respectively. Since 1987 she is an Associate Professor of Computer Science at the University of Crete and a Researcher in ICS-FORTH. She is technical co-ordinator of the THETIS project (Telematics) for the development of a distributed information system supporting Coastal Zone Management, and involved in the DECAIR project (ESPRIT) for developing a data converter for air-pollution models. Her

research interests include Performance of Parallel and Distributed Systems, Problem Solving Environments, and Environmental Information Systems.

Dr. Spyros Lalis received a doctorate in Technical Sciences and a Diploma in Informatics Engineering from the Swiss Federal Institute of Technology Zurich, in 1989 and 1994 respectively. Since 1997 he is an Adjunct Professor of Computer Science at the University of Crete and a Research Associate of ICS-FORTH. He is currently responsible for the design of the THETIS system, a distributed information system supporting Coastal Zone Management. His research interests include Programming Languages and Systems, Software Engineering, Distributed and Parallel Systems, Advanced Information Systems, Collaborative Environments, Economics of Electronic Services and Intangible Goods.

Dimitris Papadakis is a Ph.D. candidate at the Computer Science Department of the University of Crete, expected to graduate in 2001. His current research focuses on decentralized resource allocation mechanisms for open distributed systems. He holds a B.Sc. and a M.Sc. in Computer Science.

Yiota Spetsidoy (co-ordination personnel) is a postgraduate student at the School of Primary Education of the University of Crete. Her working experience includes administration of projects (Promitheas, Iphigenia, Leader).

Eva Zeta-Salifoglou (co-ordination personnel) holds a B.Sc. in Business Administration and a M.Sc. in Organisational Development. She has worked as an operations officer and business analyst, and her working experience also includes consulting, training co-ordination and accounting.

A.2.2: Partner No. 2: FORTH (Institute of Computer Science)

The Institute of Computer Science (ICS) is one of the seven institutes of the Foundation for Research and Technology Hellas (FORTH). It conducts basic and applied research, develops applications and products, and provides services in the following fields: information systems, software technology, digital telecommunications, network management, parallel architectures and distributed systems, computer vision and robotics, computer architectures, design of digital and microelectronics systems, VLSI systems, computer aided design, medical informatics and health telematics, image management and communication, human-computer interaction, assistive technology, machine learning, decision support systems, formal methods in concurrent systems, etc. Two groups from ICS/FORTH will be involved in the proposed project: PLEIADES and AT & HCI Laboratory.

The Parallel and Distributed Systems Division (PLEIADES) was established in 1992 and conducts research and development in modern distributed systems. The group is actively involved in the area of Advanced Digital Libraries, investigating mechanisms for organizing and searching through distributed collections of electronic objects, providing access to multilingual information, and developing new methods of charging the services offered. This work is further extended for Networked Scientific Repositories and Information Systems where the objective is to build advanced federated systems for transparent access and visualization of distributed scientific data, and interoperability of computation

programs, via the World Wide Web. The group also performs research in Electronic Commerce, focusing on the problems emerging in complex business interactions that acquire different types of resources from several autonomous markets. Further, the resource allocation problem in open, dynamically changing distributed systems is investigated using market-based approaches. A distributed system is viewed as an Information Economy where applications access services for a fee based on the quality of service requested, and economic models are used to achieve efficient resource allocation and service provision.

The research and development activities of the Assistive Technology & Human-Computer Interaction (AT & HCI) Laboratory focus on two main fields. In the Assistive Technology field, the objective is to support the socio-economic integration of people with disabilities, by exploiting the advances of Information and Telecommunications Technologies. In the field of Human-Computer Interaction, the objective is to facilitate the development of user interfaces for interactive applications and telematic services, that are accessible, usable and acceptable by all users in the emerging Information Society. Work at the AT & HCI Laboratory is based on the principles of "Design for All" and "Universal Accessibility" and the outcomes have contributed to the international literature the concept of "User Interfaces for All", and the Unified User Interface Development framework (methodologies and tools). The AT & HCI Laboratory also participates in international support (horizontal) activities, including studies on technical innovation and technology transfer in the Assistive Technology field, and standardisation activities in Human-Computer Interaction.

The key personnel to be involved in the proposed project will be Dr. Spyros Lalis and Dr. Constantine Stefanidis, representing the two groups of ICS/FORTH described above.

Dr. Constantine Stephanidis is Head of the Assistive Technology and Human-Computer Interaction Laboratory, at the Institute of Computer Science (ICS) of the Foundation for Research and Technology - Hellas (FORTH), Heraklion, Crete, Greece. He is Associate Professor of Human-Computer Interaction at the Department of Computer Science, University of Crete. His research interests and expertise lie in the fields of Human-Computer Interaction (HCI) and Assistive Technology (AT). Constantine Stephanidis has been the Principal Investigator of ICS-FORTH in many European collaborative R&D projects, Support Measures, and Studies, funded by the European Commission. He participates in several international scientific, technical, standardisation and research policy committees (as National Representative, or International Expert). He is member of the Programme Committee of several international scientific conferences and of the Editorial Board of scientific journals in the fields of HCI and AT. He has organised many international scientific conferences, workshops, tutorials, seminars and panels related to his fields of expertise. He has (co-) authored over 150 technical papers published in scientific archival journals and international conferences. He is the Editor of the book entitled "User Interfaces for All", to be published in 1999 by Lawrence Erlbaum Associates. Prof. Stephanidis is currently member of the Executive Committee and member of the Board of Editors of the European Research Consortium for Informatics and Mathematics (ERCIM). Since 1995, he is the Founding Chairman of the ERCIM Working Group on "User Interfaces for All" and the Organiser of the Annual International ERCIM Workshop of this

Group. Since 1997, he is the Founding Chairman of the International Scientific Forum "Towards an Information Society for All" and the Organiser of the Annual International Workshop of this Forum. He is a member of the Advisory Committee of the World Wide Web Consortium (W3C) and participates in activities of the W3C - Web Accessibility Initiative.

Demosthenes Akoumianakis received a Bachelor (Hons) on Computing in Business, from the University of Huddersfield, UK, in June 1990, and he was the recipient of the 1st IBM Price for Final Year Dissertation. His M.Sc. thesis (1995) was concerned with design environments for user adaptable interfaces. His Ph.D. thesis (1999) was on 'Knowledgeable' Tools for Evolving HCI Design - Theory and Practice. During 1988 and 1989, he was working as a Systems Analyst at the Corporate Information Systems Department of the Co-operative Wholesale Society, Central Manchester Complex, UK. Since 1993, he is a research engineer at the Assistive Technology and Human Computer Interaction Laboratory of the Institute of Computer Science, Foundation for Research and Technology - Hellas. Demosthenes Akoumianakis has been involved in several European collaborative R&D projects including: CORE TP126 and CORE TP213, the HEART study TP309, ACCESS TP1001, AVANTI AC042. His research interests include methodologies, design support environments and tools for developing adaptable and adaptive user interfaces. He has co-authored many publications in international scientific journals and conferences in the fields of Assistive Technology and Human Computer Interaction.

Dimitris Gatzouras was born in Stuttgart, Germany, on 31.12.62. He received his Diploma, in Mathematics, from the University of Athens, Greece, in 1986, and his M.Sc., in 1989 and Ph.D., in 1992, from Purdue University (U.S.A.). He then held positions at Yale, University of Crete, Cambridge University, Purdue University and holds currently a research position at the University of Crete, funded by the Greek "General Secretariat for Research and Technology".

Manolis Marazakis is a Ph.D. candidate at the Computer Science Department of the University of Crete, expected to graduate in January 2000. His current research focuses on workflow management and service-level agreements in open distributed systems. He holds a B.Sc. and a M.Sc. in Computer Science.

Antonis Hatzistamatiou holds a B.Sc. and a M.Sc. in Computer Science. He is currently working as a researcher within FORTH. His current research focuses on economics of electronic commerce, bandwidth markets and emerging patterns of interaction and collaboration on the virtual space.

Stavros Papadakis is a postgraduate student at the Computer Science Department of the University of Crete, expected to graduate in January 2000. His research interests include Web technologies, distributed information systems, digital libraries, and distance learning. He holds a B.Sc. in Computer Science.

A.2.3: Partner No. 3: Swedish Institute of Technology

Swedish Institute of Computer Science (SICS) is a non-profit research foundation. SICS mission is to contribute to the competitive strength of Swedish industry by conducting advanced and focused research in strategic areas of computer science, and by actively promoting industrial use of new research ideas and results in industry and society at large. SICS works in close collaboration with industry and the national and international research community. SICS participates actively in collaborative R&D programs, both national and international, such as Esprit and ACTS funded by the European Commission, and Real World Computing funded by the Japanese government. SICS has a well developed collaboration pattern with high-tech SMEs in Sweden, carrying out joint projects, and acting as a R&D resource for selected SMEs. SICS has a proven record of disseminating and promoting industrial deployment of its research findings, including establishing spin-off companies, as well as licensing its software and patents.

The Intelligent Systems Laboratory explores novel technologies and novel uses of technologies for a range of intelligent systems, addressing new challenges introduced by complex technical systems, complex production facilities, and not least the complex web of information and services on the Internet. Optimization technologies are applied in areas such as frequency planning, dynamic network topologies, print mask generation, steel production planning, and transportation scheduling. Intelligent software agents are developed for electronic markets, recommender services, information and service brokers, and other innovative applications for a networked world. Advanced software development platforms are developed that provide powerful programming concepts to match the new challenges.

The Agent Based Systems Group aims to provide a technical and conceptual foundation for the automation of participation, of individuals and organizations, in different forms of electronic markets. The markets studied are on one hand more specialized, e.g., bandwidth for IP telephony, railway transportation, and electric power, on the other hand more general markets for goods, services, and information. In the first case, supply and demand are for (more or less) standardized commodities, and the main problem is to achieve an efficient allocation under different circumstances while allowing participants to act in their own best interests. In the second case, supply and demand are more vague, and the main problem is to match interests of and build trust between market participants.

The Programming Technologies for Networked and Mobile Computing Group works on distributed programming and agent platforms that provide full infrastructure for developing distributed applications. The most recent platform is Mozart (http://www.mozart-oz.org) that provides a concurrent constraint and object-oriented platform for advanced distributed applications. The platform provides network transparency and awareness, mobility of objects and closure (procedures, classes), fault tolerance and resource control. Among the applications of Mozart is an advanced multiagent platform that supports FIPA compatible communication acts, extensive dialogue models (protocols), symbolic and constraint reasoning, and management of agent life-cycles.

The key personnel to be involved in the proposed project will be Professor Seif Haridi and Dr. Sverker Janson.

Professor Seif Haridi is Professor of Computer Systems at the Royal Institute of Technology and Research Director of the Swedish Institute of Computer Science. Prof. Haridi's current

research spans the areas of distributed programming systems and agent technologies. Previous research areas include constraint programming, parallel programming, and parallel computer architectures. Results from this work includes numerous publications in a wide range of areas, international patents, and well-known software systems and hardware architectures, including co-design of the distributed multi-paradigm programming platform Mozart (http://www.mozart-oz.org). He has participated in four EU projects, in one of which as co-Coordinator.

Dr. Sverker Janson is director of the Intelligent Systems Laboratory at the Swedish Institute of Computer Science. Dr. Janson's research focuses on agent-based systems and their applications to automation of Internet commerce and other, more specialized, electronic markets. Previous research areas include knowledge representation and concurrent constraint programming (CCP). Results include publications, patents, and software systems, including a complete CCP development environment and commercially exploitable prototype applications in agent-based Internet commerce and component-based software. He has participated in two EU projects, in one of which as co-Coordinator.

Fredrik Holmgren Ph.Lic., is a member of the Intelligent Systems Laboratory at the Swedish Institute of Computer Science. His current research focuses on multi-agent systems, especially agent communication languages and agent architectures. Previous research areas include formal grammars and logic programming for knowledge representation. Results from his work are experimental platforms, reports and two prototype software systems for checking design rule conformance on real-world electronic designs.

Erik Klintskog is a Ph.D. student at the Intelligent Systems Laboratory at the Swedish Institute of Computer Science. His research focuses on distributed programming systems and their implementations. Previous research areas include multi-user distributed environments. He is a co-developer of the distributed multiparadigm programming platform Mozart (http://www.mozart-oz.org).

Andreas Rasmusson holds a M.Sc. in Computer Science, from the Royal Institute of Technology in Stockholm, since 1997. He has been working in the Agent Based Digital Libraries project at SICS/ISL since early 1998. His M.Sc. thesis concerned an architecture for enabling trust in communities where mobile agents, or untrusted code in general, is used. His main interests concern the issues of analysing and building large systems where people with different motivations participate with solutions and services, e.g. heterogeneous distributed systems or agent systems.

A.2.4: Partner No. 4: Ecole Polytechnique (Laboratoire de l'Econometrie)

The research conducted at the Laboratory of Econometrics presents a dominant focus on micro-economics, with emphasis on formal methods and models for a large variety of applications. This

research is pursued along two premises: work on problems related to social welfare; development of mathematical and computational methods for the economic analysis and more generally the study of strategic interactions. Taking into account the originality of its orientation, the Laboratory maintains privileged relationships with a variety of organizations, apart from the scientific community, including ministries (Equipment, Environment, Domestic Affairs, General Secretariat of Planning), public organizations (World Bank, UE, OCDE, National Parliaments) and private enterprises both in France and abroad.

The Laboratory is especially open to the international scientific community. It maintains regular collaborations with a certain number of foreign universities (visitors, conferences, joint organization of colloquia, collaboration programs on various topics), and especially with the University of Louvain-La-Neuve (CORE), the London School of Economics, the University of California at Santa Barbara (Department of Applied Probability and Statistics), the State University of New York at Stony Brook (Institute for Decision Sciences, whose founder is a member of the Laboratory), the University of Delaware (Disaster Research Center), the University of Montreal (Department of Economic Sciences), the University of Leyden (Department of Public Administration), the Industrial Crisis Institute of New York, the Tokyo Metropolitan University (Center for Urban Studies), the Universidad de Chile (Departamento de Ingeniera Matematica), the Universitad Catolica de Chili, the Hebrew University of Jerusalem (Center for Rationality), Tel Aviv University (Mathematical Sciences, Economics, Business School), and the Limburg University at Maastricht (Department of Mathematics).

The key personnel to be involved in the proposed project will be Dr. Herve Tanguy and Dr. Petros Kavassalis.

Dr. Herve Tanguy (Ecole Polytechnique and Ph.D. in management) is Research Director in Industrial Organization and Managerial Economics at the Laboratory of Econometrics, Ecole Polytechnique Paris and INRA (Institut National de la Recherche Agronomique). His main theoretical focus deals with two issues: organization within firms (coordinating, planning and contracting) and vertical relationships between suppliers and distributors in several competitive settings (quality differentiation, bypass possibilities...). He is particularly interested with applications in the agro-business industry and especially the wine sector: his interventions as expert in the vine and wine growing industry (Champagne, Burgundy, Val de Loire) deal with supply regulation problems, designing optimal long term contracts and international competitive strategies for transformers and distributors.

Dr. Petros Kavassalis has en Engineering Degree from the National Technical University of Athens and a Ph.D. on Economics and Management from the Dauphine University at Paris. He is working as Researcher with Ecole Polytechnique (Centre de Recherche en Gestion et, more recently, Laboratoire de l'Econometrie) since 1991. He is also actively participating in the MIT Internet Telecommunications Convergence Consortium. His main areas of research include organisational design and allocation of resources over the Internet, electronic commerce and electronic intermediation and, more generally, the economics and management of technical change (emergent institutions, patterns of change and dynamic organization etc.).

A.2.5: Partner No. 5: IBM T.J. Watson Research Center (Institute for Advanced Commerce)

The IBM Institute for Advanced Commerce (IAC) is a forum for the examination of fundamental shifts in business and trade. National and international trade, business operations, and general society are all dramatically impacted by the emergence of electronic commerce. The Institute, through a series of conferences and university partnerships, addresses market and business concerns with a goal of developing long-term replicable commerce solutions to meet corporate needs. Major research themes for IAC include the evolving marketplace, privacy, variable prices and negotiated dealings, direct business-to-business interactions, managing the end customer, impact of globalization, deep computing for commerce, and system foundations.

The key personnel to be involved in the proposed project will be Dr. Jakka Sairamesh.

Dr. Jakka Sairamesh has been actively pursuing research in the areas of economics and dynamics of electronic commerce systems, information and computational economies, electronic marketplaces and intermediaries, simulation models for decentralized systems, middleware for electronic commerce, and network resource allocation and management. He has many years of experience in modeling and analyzing large-scale systems using economic models. Dr. Jakka Sairamesh has a Ph.D. in Computer Science from Columbia University, New York. He was one of the organizers of the First Conference on Information and Computation Economies, which was held in Charleston, South Carolina, USA, in October 1998, and a co-chair of the 7th DELOS Workshop on Electronic Commerce, which was held in conjunction with the 2nd European Conference on Digital Libraries in Heraklion, Crete, Greece, in September 1998. He has also participated in EU projects, when he was in Europe as a visiting research staff at ICS-FORTH, working in the areas of digital libraries, electronic commerce and transaction processing systems. His current area of interest is in Electronic Marketplaces, E-commerce, Economics of Information and Computation and mathematics of auctions. He has published many papers (conferences, workshops and Journals) in the area of electronic commerce and information economies. He has given several invited presentations on topics related to Electronic Marketplaces, Network Bandwidth Pricing, Information Economies. He has also taught courses at Columbia University, Computer Science department on Information and Computation Economies. He has a strong mathematical background and computer science background. He also has strong background in mathematical economics. He has applied his skills in modeling large scale computer systems and information systems using economic paradigms.

A.3: Contact Information

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Appendix B – Contract Preparation Forms