European Cooperation in the field of Scientific and Technical Research - COST -

Secretariat

Brussels, 11 December 2008

COST 261/08

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding for the implementation of a European Concerted Research Action designated as Cost Action IC0804: Energy efficiency in large scale distributed systems

Delegations will find attached the Memorandum of Understanding for COST Action IC0804 as approved by the COST Committee of Senior Officials (CSO) at its 172nd meeting on 24-25 November 2008.

MEMORANDUM OF UNDERSTANDING

For the implementation of a European Concerted Research Action designated as

COST Action IC0804

ENERGY EFFICIENCY IN LARGE SCALE DISTRIBUTED SYSTEMS

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 270/07 "Rules and Procedures for Implementing COST Actions", or in any new document amending or replacing it, the contents of which the Parties are fully aware of.

2. The main objective of the Action is to foster original research initiatives addressing energy awareness/saving and to increase the overall impact of European research in the field of energy efficiency in distributed systems.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 44 million in 2008 prices.

4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter V of the document referred to in Point 1 above.

A. ABSTRACT AND KEYWORDS

This COST Action will propose realistic energy-efficient alternate solutions to share distributed resources. As large scale distributed systems gather and share more and more computing nodes and storage resources, their energy consumption is exponentially increasing. While much effort is nowadays put into hardware specific solutions to lower energy consumptions, the need for a complementary approach is necessary at the distributed system level, i.e. middleware, network and applications. The Action will characterize the energy consumption and energy efficiencies of distributed applications. Then based on the current hardware adaptation possibilities and innovative algorithms it will propose adaptive and alternative approaches taking into account the energy saving dimension of the problem. The Action will characterize the trade-off between energy savings and functional and non-functional parameters, including the economic dimension.

A COST Action is the right framework to unite a dispersed community and to promote the dissemination of the solutions and the energy concerns to the broader public. Deliverables will include workshop proceedings, books, good practice leaflets fostering consciousness rise at ICT researchers, scientists, managers and users levels. Finally, benefits will address scientific and societal needs.

Keywords: Energy-saving, Distributed systems, Energy-awareness, Resource sharing, Power-consumption

B. BACKGROUND

B.1 General background

It is analysed that the 1.5 billion computers in the world use about 90000 MW of electric power, which is about 10% of the global consumption. The latest in-depth survey ("Electricity Consumption and Efficiency Trends in the Enlarged European Union", Institute for Environment and Sustainability, 2007) commissioned by the European Union in 2006 about energy consumption and efficiency of equipment in buildings shows a continuous growth of energy consumption of

computer end-use equipments (amongst others) over the last years. Additionally, the world energy consumption for servers has doubled over the period from 2000 to 2005. At the CeBit forum 2008 in Hannover, the world's largest technology fair, recent shocking estimates proclaim that worldwide Internet usage needs the equivalent of 14 power stations to power the required computers and servers, producing the same amount of carbon emissions as the entire airline industry. As for an example, an operational Grid like EGEE (Enabling Grid for E-sciEnce) is constituted from more than 41,000 computer nodes, distributed in 45 countries and 240 sites. The world top 500 most powerful machines have more than 1.2 millions processors. To the raw electric consumption, one can add the energy costs in terms of air conditioning and cooling infrastructures.

The large-scale distributed systems (clusters, grids, clouds, P2P systems) are nowadays gathering transparently more and more resources to store, to compute and to communicate data and services around the world for the common benefit of many users. Cost-effective solutions are defined in terms of euros per solution. Distributed Computing, Grid Computing and most recently Cloud Computing attempt to ameliorate the personal cost of ownership by straddling ownership boundaries and taking advantage of economies of scale.

Traditionally, there has been a dearth of eco-awareness in the computing industry. Moore's Law has not led to overall power savings as miniaturization would allow. Instead, greater capacity and capability have invariably taken precedence over eco-concerns. Despite the fact that the energy dimension was taken into account since several years in mobile and embedded systems, the total collective costs of large-scale distributed technologies have not traditionally prioritized ecological concerns. Ecological impacts constitute a silent cost which until recently has largely been ignored. But recent studies charged from government institution are going to consider energy efficiency procedures mainly for server and data centres. An example is the report of the US Environment Protection Agency (EPA) delivered on August 2007 to the congress.

This Action aims at giving voice to this cost. Central to this approach is the recognition that environmental resources need to be effectively managed as an integral part of every computation - just as processing cycles, storage and bandwidth are currently routinely managed in every computation.

The research topic of the Action is the investigation of realistic energy-efficient alternate solutions (software, middleware, networking) to share distributed resources.

The start of a COST Action on the energy-efficient distributed systems theme will permit to structure and federate a disseminated and disparate community in Europe. At this early stage of energy efficiency research in distributed systems a COST Action fosters the formation of a worldwide visible forum on this specific topic. Currently few scientific events are dedicated to this theme. Only two workshops exist: HPCCA at the IPDPS conference and GreenCom at the Cluster 2007 conference.

The Action will promote research carried out in each particular domain of energy efficient distributed systems (parallel computing, server farms, Grids,P2P, home environments, etc.), which would lack impact when being researched separately. These different domains will benefit from exchanges of approaches and results enabled in the COST Action. It will allow researchers to discuss different related and complimentary aspects on energy-efficiency in distributed systems.

B.2 Current state of knowledge

Many of the current green activities represent isolated optimizations; others attempt to standardize approaches and solutions and to promote a common understanding of the issues and complexities. While recognizing their vital importance, this proposal goes beyond human-centred operational procedures and piecemeal technological solutions. Decades of work in Distributed and Heterogeneous Systems attest that solutions exist to share efficiently complex and diverse resources and the literature is replete with such solutions and experiences. Moreover, sharing has been demonstrated to be an efficient solution to optimize resources usage.

Recent initiatives gathering major IT companies started to explore the energy saving side of computing infrastructure. For instance, the Green Grid, a non-profit trade organization constituted from more than 50 major companies is dedicated to advancing energy efficiency in data centres and business computing ecosystems. It develops relevant standards, metrics, processes and technologies to improve performance, and promotes their widespread adoption. Several major IT companies have announced plans to either save energy for their infrastructure (planning the buildings of the data centres, the locations of air conditioners according to the heat dispersion, etc.) or to use green energy. Additionally they investigate approaches relying most of the time on more energy-efficient hardware (in particular power supplies). They often neglect the services themselves and the distributed systems that run these services and, e.g., can save energy by sharing resources in an energy efficient way.

Earlier research efforts have focused on proposing effective power management techniques that are employed at different levels:
1. Architecture: Various infrastructures that vary from wireless sensor networks to hard disks. Coming back to 1994, earlier work has considered mechanisms that analyze possible power savings at the circuits/chip level using voltage scaling;
2. Hardware: Special attention is given to future mass applications with strong computer resources requirements like video coding and compression. For this purpose programmable hardware like Field Programmable Gate Arrays (FPGA) technology is used for shorting computer time and improving energy savings;
3. Operating System: Some researchers use an embedded micro-operating system to reduce node energy consumption by exploiting both sleep states and active power management;
4. Resources level: Dynamic power management (DPM) exploits idle devices and resources to reduce load inefficiencies and balance energy consumption.

These studies were mainly conducted when considering independently each node of a distributed system. While important and not to be neglected in the approach of the Action, the Action will investigate innovative distributed approaches that will rely partly on these works acting on individual resources.

For the home networking domain, powering or slowing down parts of home computer hardware can save energy. By monitoring users interaction, and applications behaviour, additional power-adaptive mechanisms can be switched on (e.g., incrementally turning off different hardware parts) or applications can be migrated (e.g., leading to powering down unused computers). These studies show that energy can be saved and energy efficiency can be increased by resource sharing.

In cluster computing environments, researchers investigate energy efficient resource sharing at different levels:

a. From the networking point of view, they try to either limit the number of messages being exchanged or to adapt the communication protocols themselves. For instance, researchers shown that adapting a message passing library of communication (like MPI) can decrease the energy consumption by 12% while decreasing performances by only 2,1%;

b. Another leverage of action that is studied is the possibility to schedule the tasks of the distributed system (mainly heterogeneous ones like Grids for instance) and to migrate them according to the power consumption of the individual nodes or the temperatures at the nodes location. Some early works were even considering the allocation of the tasks in a given cluster according to the heat dispersion of the nodes in a physical location;

c. Another example reflects some works done on the data replication and data placement in order to limit both their number and their communications, decreasing energy consumption at the infrastructure levels (routers, storage, processing units).

Virtualization in distributed systems, in particular using virtual machines in order to encapsulate the behaviour of the applications so that their migration is facilitated, is another direction of research actually investigated with the overall objective to reduce the energy consumption while maintaining a given quality of service.

Finally, one of the difficulties that may arise is to maintain fair resource sharing. Some works have been done in this area modelling the usage of the shared resources with an economic dimension.

The scientific community on the energy saving theme is blooming as the interest of governments and researchers increased exponentially in the last years. In the early 2000, limited works done in the USA (project Green Destiny) and Japan launched the first interests in the energy-aware computing. Recently, some initiatives, mainly in the USA, address this problem: Green Internet, Green 500, to name a few.

In Europe, initiatives at the scale of one country (ARC Inria Green-Net, France), or cooperation inside the framework of the existing 6th Framework Programme Network of Excellence (NoE) Euro FGI project (subproject Virtual Home Environment), started to investigate partly these issues in the last year. This subproject investigates energy efficient home networking by means of resource sharing and virtualization of resources.

More recently, the AIM project (answer to the ICT-2007.6.3 ICT call for environmental management and energy efficiency, ICT-224621) aims at managing and integrating energy consumption of home appliances. The project aims at conceiving autonomous, self-programmable mechanisms for stand-by state detection and power off, using all-device-fit, harmonised, own-developed interfaces. It remains a local and not distributed approach, and especially not for ICT resources.

The BE-AWARE project (Boosting Energy AWAREness with adaptive real-time environments, answer to the ICT-2007.6.3 ICT call for environmental management and energy efficiency, ICT-224557) uses as leitmotiv that users can adapt actively their behaviour to energy saving with suitable feedbacks, support, and incentives, reducing significantly and cost-effectively energy use without impacting adversely their comfort. The approach of BE-AWARE is complementary to this COST Action since it states that awareness of the ecological impact changes the behaviour of users.

B.3 Reasons for the Action

The objective of this Action is to concentrate European research on energy efficiency with a particular focus on distributed systems as the lack and dispersion within this research focus was outlined in the preceding section B1. In such a context, open research problems remain and this Action will contribute in emphasizing the fact that resource sharing can be employed to save energy and increase energy efficiency.

The immediate expected outcomes of the project are:
- increasing energy efficiency awareness by developing joint activities and publications in the field of energy saving distributed systems. Acts of exchanging researchers (faculties, PhD students), consortium plenary meetings and workshops, and focused working meetings will increase the understanding and promote research acts on this topic;
- impacting the information technology as well as the societal side by disseminating energy saving good practices and experiences. Questions like is it really possible to save energy while guaranteeing a certain level of performance in distributed systems? Which kind of distributed systems can be entitled to increase their energy efficiency?, will find some partial answers under this COST Action.

In terms of the future benefits, this Action focusing on software and distributed systems solutions will serve as a forum for complementary research contribution to initiatives in the US and Japan which primarily target energy-aware hardware. The Action envisages a potential for future cooperation and not doubled investigations and competitions.

Moreover, the Action will have a societal and environmental impact. Saving energy has become a national priority in many European countries; the European Union is setting many actions to decrease its consumption of carbon gas, to meet international agreement and to raise the ecological awareness in the general public and industry CEO. This Action enters literally in these initiatives, building from eco-aware to eco-friendly alternate solutions in distributed ICT.

Thus, the Action is beneficial from both a scientific/technological and economic/societal point of view.

B.4 Complementarity with other research programmes

At European level, the environmental research themes are not investigating the issues related to the electric consumption in the Information Technology. In the 7th Framework Programme (FP7), the Energy theme is concerned with the Energy consumption and production. The FP7 Environment theme focuses its actions on environmental issues and climate change, but nothing is done on the ICT side.

For the ICT theme, the COST Action fits into the Challenge 1 on Pervasive and Trusted Network and Service Infrastructure, particularly the Objectives 1 and 2, and in the FET Open Call. More particularly, ICT Challenge 6 on Mobility, environmental sustainability and energy efficiency addresses this question.

These programmes raised a number of projects including at least eco-awareness. The Action will serve as a means to coordinate more focused initiatives. Moreover the initiatives around the Future Internet promoted in Europe pave the ways for ubiquitous, distributed and collaborative approaches.

As for examples (see also part B.2 for details), the Virtual Home Environment (VHE) project, a specific subproject of the European NoE Euro-FGI has been carried out on energy efficient home networking. In the FP7 call, the AIM and the BE-AWARE projects (answers to the ICT-2007.6.3 ICT call for environmental management and energy efficiency, ICT-224621 and ICT-224557 respectively) investigate complementary approaches with different perspectives.

C. OBJECTIVES AND BENEFITS

C.1 Main/primary objectives

The main objective of the Action is to foster original research initiatives addressing energy awareness/saving and to increase the overall impact of European research in the field of energy efficiency in distributed systems.

The goal of the Action is to give coherence to the European research agenda in the field, by promoting coordination and encouraging discussions among the individual research groups, sharing of operational know-how (lessons-learned, problems found during practical energy measurements and estimates, ideas for real-world exploitation of energy aware techniques, etc.).The Action objectives can be summarized on scientific and societal points of view: sharing and merging existing practices will lead the Action to propose and disseminate innovative approaches, techniques and algorithms for saving energy while enforcing given Quality of Service (QoS) requirements. Notably the different leverages must be regarded together since they might influence each other (deliverables: position paper/survey on existing practices; innovative ideas guidelines/brochures, workshop proceedings, book on the projects topic, summer schools). The Action will create a common forum bridging scientific societies from various origins in computer science from architecture to applications (deliverables: project wiki, discussion lists, postings at popular scientific forums, newsletters). The Action will take particular care of the openness and the applicability of the proposed solutions in a wide spectrum of distributed systems (deliverables: best-case scenarios lists, white papers on Good practises). To broaden the Action societal impact, it will support and raise consciousness in energy saving for different audiences: system administrators, experienced scientists and engineers, industry CEO, general public, etc (deliverables: everyday guides and leaflets, web portal and wiki, blogs of the projects partners, newsletters). To perfect the adoption of energy awareness, the Action will devise economic studies and evaluate gains from energy savings of the different leverages (deliverables: statistical summary and overview).

C.2 Secondary objectives

The Action aims at becoming the main reference point for European research in the field of energy efficiency in distributed systems. This in turn would facilitate the launch of collaborations and joint focused activities within the European community and with non-European entities working on the same field. The Action will become an attraction point for researchers interested in taking into account the energy consumption in their work, also beyond the distributed systems community.

C.3 How will the objectives be achieved?

The objectives detailed in the previous parts will be achieved by different means, including:
- The management and coordination parts which reflect in the Action organization in terms of Management Committee (MC), Working Groups (WG), Focus Groups (FG) and links between them (see part E for details);
- Organization of workshops (1 per year) where the researchers will interact and have a global view of the project, also inviting some external experts especially from industry players;
- Organization of summer schools for young researchers that will gather knowledge on the different initiatives;
- Short visits of researchers, especially early-stage researchers;
- Dissemination activities towards consciousness raising: a dissemination board will be responsible for the advertisement of the Action activities, including the production of regular newsletters to inform the wider audience of the current trends being investigated in the Action; manpower and equipment will be needed to support this activity and to host the Web site of the Action, the wiki, ;
- The production of an annual report on the Action progress;
- The common investment in equipments used as common referential on measuring power consumption in order to infer some global comparisons between the different approaches.

C.4 Benefits of the Action

The high-level Action benefits can be summarized as follows (ref. Section B and C1).

- Fostering a European forum visible worldwide on energy-efficiency in distributed systems;
- Increasing the coherence of the European research on energy-efficient distributed systems;
- Increasing the cross-fertilization of scientists coming from different communities;
- Developing international collaborations and exchanges, also from young and early-stage researchers;
- Taking into consideration the ecological impact of the heavy computations and communications arising in distributed systems;
- Raising consciousness on the energy hungry computations;
- Raising consciousness on the possibilities for the distributed system to adapt appropriately to decrease the energy consumptions while guaranteeing performances;
- Reducing the energy consumption of the informatics ecosystem on the long term.

C.5 Target groups/end users

The first beneficiaries of the Action will be the researchers involved in initiatives on energy savings in distributed systems. Gathering European scientists is the major role of the Action. The Action will create the appropriate forum for discussing and exchanging ideas about the topic.

The Action will also serve as a unified reference point for the European research community at large and researchers from other fields to explore inter-disciplinary collaborations: For instance researchers from ecology, mathematics, and economics will be interested in the Action.

Second, industry players will find several interests in the results of the Action: hardware constructors will exhibit the possibilities of their solutions in real distributed applications; middleware vendors will advertise the potentiality of saving energy thanks to their products following the initiatives promoted by the Action; software developers will have a choice of approaches and innovative algorithms to construct energy efficient software to be integrated in

solutions for customers. These will be some remarkable benefits for the industry players that will be able to advertise their product as being compliant with energy-saving good practises. Moreover the expected spin-offs of the Action will allow the European industry players to hold the leadership in the green ICT future.

Policy makers (European, national and local) involved in the decision of project funding and research pathway will find in the Action dissemination activities (reports, newsletter, web portal) the necessary information to have a clear idea on the current state of the European research on this topic. Moreover the Action will serve as a reference point to provide experts on this subject relevant information to be able to reply to potential questions raised by the policy makers.

The general public will take benefits from the Action.

First, scientists and engineers doing some computational intensive researches on distributed systems (like Grids or clusters for instance) will be able to measure their ecological impacts (they will probably be asked for it in the near future). System administrators will have a clear understanding on the consumption of their infrastructure and some hints on how to improve the situation (thanks to the dissemination activities).

Industry CEOs will be targeted to improve their insight into new alternate solutions consuming less energy for equivalent quality of services.

Finally, individuals participating in Internet-wide distributed systems (like home networking and Peer to Peer networks for instance) will also benefit by reducing energy consumption and wastage (maybe indirectly since the improvements might be hidden to them as integrated in the software, the middleware, the network they use).

Last but not least, the Action will improve energy efficiency in all computer related domains by increasing the consciousness and creating a dynamic, transparent integration of eco-friendly solutions.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

To pursue the goal of eco-aware and ultimately eco-friendly computing a number of novel concepts and innovative tools are needed. A computation is defined to be eco-aware if it has direct knowledge of the quantity and quality of eco-resources it is expending. Vesting this knowledge in each computation is crucial for the creation of an appropriate distributed management framework in which these computations unfold. This eco-awareness will provide information on ecological impact and monitoring this information will underline both positive and negative trends. This information will be invaluable in devising deployment strategies and in measuring their success. Going from eco-awareness to eco-friendliness constrains computations to execute taking into account the ecological and potentially the economic impact of the used resources. Conforming to these constraints will require imaginative solutions that are sometimes complicated by the need to respect conflicting constraints such as security, time to solution or budget.

The solutions to achieve better energy efficiency in sharing distributed resources will address different topics.

First, the current possibilities of on-the-fly adaptation of the underlying hardware behaviour will be studied: for instance it is possible to decrease the voltage of the processors to slow them down and save energy. The Action will also integrate in its study futuristic means of adaptation that are just being discussed nowadays at the constructors' sites. These characteristics will permit to have a clear idea of the direct possibilities of leverages with respect to the underlying infrastructure. New and future core technologies will be taken into account since they may enable drastic reduction of power consumption and thus deeply change the problem landscape, as it would be for instance through optical processing. The infrastructures of the involved institutions, diverse and heterogeneous in nature, will serve as the basis for such a study.

Second, there will be the need to characterize the electrical consumption of the distributed systems, as a function of the load of the system. Here the term system includes in the same framework the software, middleware and networking layers of a distributed application. This implies first to have a means to measure or estimate the energy consumption volume (by actual power-consumption measurement equipments), and then to model the behaviour of the computations related to the obtained performances. The economic dimension will be taken into account by including in the cost of a computation both the euro-cost and the eco-cost, meaning combining the actual cost of the computation and its ecological impact.

Third, actions have to be taken at different levels of decision to improve the energy-efficiency of the distributed solution. The Action will investigate several opportunities in distributed systems, at the operating system/middleware level, at the network level and at the application level. Indeed possibilities exist for the algorithmic-oriented power savings research at each of these levels of abstraction of a distributed system.

At the middleware level, the focus will be put on computational efficiency, load balancing tasks scheduling and tasks distribution. Computational efficiency is typically gained by following the idea “get the job done quickly and let the CPU go to idle to save energy”. When idled, some nodes will be shut down if low-loaded and their remaining load will be distributed to other nodes while maintaining performances. However, in more complex models, energy efficient platform configurations may require that the system operating point is always kept within a relative narrow area in terms of resource (i.e., cpu, memory, storage, etc.) utilization. Techniques inspired from control theory and autonomic computing help meeting and guaranteeing such objectives with a view to minimizing the average energy consumption per fixed size workloads. Another example is the scheduling of tasks and data in the distributed system that will take into account the energy consumption of individual machines and map it with the expected consumption behaviour of the system to find the best fit;

At the networking level, the idea will be to decrease the overall usage of the network. Moving large amount of data will operate on routes consuming less energy and the placement of the data (or the replication of the data) will be optimized to minimize the equipment usage; complementarily, approaches to minimizing the time to transfer the data, and to reducing the data to be transmitted (e.g., by using forecasting techniques) will be investigated.

At the application level, context awareness of the applications will be favoured: it aims at developing applications that are aware of the power state of the computers and the currently set power policy, such that they are tuned appropriately, and respond to changes dynamically. Developing energy-aware data mining techniques will support energy efficiency at the applications level. For instance, clustering/classifying of data sources, identifying usage patterns and cluster users will help to decrease the energy consumed in the network.

Possibilities in this part are numerous and are only limited by the imagination of the Action members. Therefore the current members of the consortium investigate these actions in different directions including both technical and economical aspects and corresponding models. Additionally approaches will be added during the course of the Action and with the joining of new members.

Fourth, trade-off between the systems functional and non-functional parameters (such as reliability, QoS, security and privacy, performance, throughput, etc.) in respect to energy-saving and economic dimension will be characterized to help the decision process at the application level. Also, results leading to contradictory solutions will be taken into account. Some examples: a non critical distributed application that has no real-time constraints can accept a slight delay in the production of some part of a results if it implies a big energy saving and a budget drop; a parallel application can be synchronized as to slow down the faster processing units to the slowest unit, using the energy saving possibilities of the respective hardware; data placement optimization at the middleware level (increasing for instance the number of replicas) can contradict data movement at the networking level (minimizing the data transfers).

Fifth, the Action will define a layered approach for supporting energy efficiency at the different levels (hardware operating system middleware network applications). The Action will define a common framework for the developments of the approaches during its course. The Action, and particularly its MC, will take care of the openness of the framework, the modularity of the proposed tools, approaches and algorithms and will privilege the conformance to appropriate standards. Continuous discussions between researchers will allow avoiding duplicate investigations as well as separate and non-interoperable solutions.

Finally, from all the possibilities of leverages, the Action will propose good practices and innovative solutions that guarantee performances with stressed energy consumption.

D.2 Scientific work plan – methods and means

The Action will be organized in Working Groups (WG) addressing the different topics raised in D.1 and coordinating the Action for a common understanding of the activities.

WG1: State of the art and continuous learning of hardware adaptation possibilities.
This Working Group will gather the participants experiences and knowledge about the possibilities to adapt the underlying infrastructures of the distributed systems in order to decrease its energy consumptions, from an hardware piecemeal perspective: individual components of the system must be regarded separately (CPUs, network cards, disks,…). This Working Group will also invite some key speakers especially from hardware research groups and industry constructors to have up-to-date information (also some futuristic trends and technical shifts like optical computers) about these possibilities.

Deliverables: a reference brochure on hardware possibilities to decrease energy consumption.
Dates: The Action will produce a first version after 6 months that will be updated regularly during the course of the Action, and at least once per year.

WG2: Characterization of energy consumption and energy efficiency.
This Working Group will find appropriate definitions for energy efficiency and investigate the energy consumption and efficiency for system components (like routers, PCs, clusters, servers) to the whole distributed systems (taking into account the potential influence of one part to another). The relationship between resources sharing and energy consumption will be evaluated establishing the corresponding cost models (including euro-costs). The Action will introduce a measurable metric to establish adaptive solutions.

To this end, the energy consumption must first be evaluated precisely thus the participants will activate when possible the same measurement equipment, or at least will calibrate their own equipments to a common reference point. This part is mandatory to be able to compare the different approaches promoted in the Action (by WG3).

This Working Group may raise two Focus Groups on two sides, energy estimation and energy efficiency characterization.

Deliverables:
- Calibration tools and methodologies to overpass the heterogeneous and dispersed nature of the equipments;
- Common research papers introducing several cost models for characterising energy consumption of different components and of a whole system.

Dates: Year 1 for the first deliverable; Year 2 for the first version of the second deliverable that will be improved every year afterwards

WG3: Adaptive actions for distributed systems.
This Working Group will define some possible actions that can be taken when energy cost is known, at the middleware, network and applications levels. The efficiency of the different actions to be undertaken will be evaluated thanks to the cost models introduced by WG2 when these become available.

This Working Group will certainly create several Focus Groups investigating in parallel several approaches at the different levels of a distributed system infrastructure.

Deliverables: Several research papers investigating the focuses from different perspectives.

Dates: During the whole course of the project. It is expected that first results will appear at Year 1 onward so that a large number of results can act as inputs for the WG4 as soon as Year 2.

WG4: Characterization of performance-energy saving trade-off.
Cost model based metric establishes a new scenario with differentiated socio-economic behaviours, resulting a new type of business clusters. Analytical optimisation models and their implementation by corresponding algorithms will be used, supported and verified by simulation models and programs. Measurable outcomes in terms of energy savings (watts saved) will be produced.

Deliverables: Research papers understanding mutual influences of the different approaches investigated by WG3.

Dates: Year 2 onward.

WG5: Scientific coordination and dissemination of the works and definition of a common opened framework.

Deliverables:
- Integration workshop proceedings;
- A book encompassing and gathering the whole experience;
- Leaflets and good practises;
- A white paper defining the basis of the architecture and principles of the common framework.

Dates: During the whole course of the project. Book delivered at the end of the Action. Leaflets and good practises starting at Year 2. White paper delivered at end of Year 1 after the first integration workshop.

COST is the most suitable framework for gathering the energy of the different Action members. The members will individually (or in subgroups) explore various leverages to improve energy efficiency, proposing advances in research taking into account some hardware adaptation possibilities.

Links between the work packages are foreseen as follow:

WG1 will gather information during the course of the project and deliver a document about the current hardware possibilities on which innovative algorithms and approaches can be developed. This continuous learning will be used and updated regularly by the Action members. It will be useful for WG2, 3 and 4.

WG2 estimation and modelling of energy consumption will, together with the different possibilities of adaptations of the distributed systems evaluated inWG3, serve as continuous inputs to the characterization of trade-off by WG4.

Works done in WG1, 2, 3 and 4 will be put in perspective in WG5 in order to have broader views and consistencies of the different conducted researches.

The different scientific approaches will nourish each other from the experiences of the Action members.

Experiences in cost-models to control adaptations, investigation of self-organization and decentralized distributed solutions, grid perspective, virtualization of networked systems, applications from home networking and grid applications, to name a few, will be interesting to integrate in the Action.

Since a distributed system is a whole that must take into account hardware, middleware, software and network, cross-fertilization of the approaches from distinct but related fields is expected. The different approaches that will be studied by the different Action members will be complimentary with some necessary overlap. This is also reflected by the vertical organization of the WGs, fostering coordination and integration between participants.

Industry will be potentially involved to reflect the levels of the Action, from the capture of energy consumption, the communication and large scale computing infrastructure, to the development and deployment of software and application. They will contribute to the Action, at least as key-speakers at some of the meetings and workshops.

E. ORGANISATION

E.1 Coordination and organisation

The members of this COST Action will form a Management Committee (MC). Following COST Guidelines “Rules and procedures for implementing COST Actions”, this MC will be in charge of the overall supervision of the Action.

The participation in the COST Action during the first stage will be promoted by actively advertising it in relevant conferences, journals, web pages and mailing lists, so as to permit to expand the geographical base of the Action and enhance the dialogue and the generation of new ideas.

The Management Committee will meet at least every six months and its main responsibilities are:
- To plan and coordinate the different meetings: MC meetings, scientific meetings as well as workshops, conferences, Short-Term Scientific Missions (STSMs), Summer schools in order to meet the objectives of the Action;
- To plan and design the activities of the Action;
- To supervise their implementation and monitor their progress;

- To allocate resources;
- To promote collaboration and exchange of knowledge (and data) between the partners from different WGs;
- To facilitate the exchange of knowledge, and to encourage multidisciplinary training for young scientists by contacts and networks.

The MC will prepare and present an annual scientific programme of the Action, annual progress reports and the final report after the completion of the Action. An Administrative Coordinator will be in charge of maintaining the communications with the National COST Coordinators, of expanding the network activities by involving new participants and of the interaction with the COST Office and other research programmes.

Each Working Group will nominate a WG Steering Board (WGSB) that will coordinate the WG specific activities. The WGSB will organize the scientific meetings to take place after each MC meeting The Management Committee and the Working Groups will also hold virtual meetings to deal with day-to-day management issues (e.g. coordination of the different activities, etc.) using web based tools every three months. Therefore also WG Chairs will be nominated by the Management Committee. Research in this COST Action will be primarily based on the Working Groups with a strong emphasis in horizontal contacts across the Action and coordination between Working Groups to exchange research directions, information and expertise.

The members will be encouraged to create freely new small Focus Groups (FG), within or across Working Groups, where specific subjects are investigated. The ultimate goal of each FG is to support operational collaborations between the partners interested in specific topics: organize student/PhD exchanges (e.g. with STSM), carry on joint laboratory activities, and produce joint publications. Young researchers will be encouraged to take an active role in starting and leading new FG. The achievements of each FG will be reported regularly to the WG and MC meetings.

Half of the MC meetings will be integrated within a workshop or conference organized by the participants. External key speakers, also from other disciplines and/or from industry, will be invited regularly to attend the scientific meetings and to give seminars or talks. All workshops/conferences will be open to the general scientific/engineering public.

A Summer School will be organised every year starting from Year 2, conditioned to budget availability for such initiative. Target audiences are PhD students and young researchers willing to take part in such activities. Like the workshops and conferences also the Summer Schools should give a scientific view to the activities of the Action.

A Dissemination Board (DB) will be nominated. It will be responsible for preparing the dissemination plan. This will include a general time schedule for the major dissemination tools. This plan will be updated regularly and added to the annual report. The DB will be responsible that the partners agree on the dissemination within a defined time and working frame. It will also assure that the deliverables of the partners are delivered on time and that the different dissemination methods are properly used before and after the Action run time. Therefore it will also have to assess and control the financial viability of these activities.

E.2 Working Groups

The Action will be organized vertically in Working Groups reflecting the proposed scientific programme described in section D2.

WG1: State of the art and continuous learning of hardware adaptation possibilities
WG2: Characterization of energy consumption and energy efficiency
WG3: Adaptive actions for distributed systems.
WG4: Characterization of performance-energy saving trade-off.
WG5: Scientific coordination and dissemination of the works and definition of a common opened framework.

E.3 Liaison and interaction with other research programmes

The Action will interact with several other initiatives.

- The Action will establish links with the European Networks of Excellence (NoE) COREGRID (FP6) and Euro-NF (FP7) since they gather a lot of researchers involved in the distributed systems community;
- The OneLab2 Integrated Project (IP) in the FP7 IST FIRE initiative provides an open federated laboratory that supports network research for the future Internet. The EGEE III project (Enabling Grids for E-sciencE,FP7, RI222667) brings together experts with the common aim of building on recent advances in Grid technology and developing an infrastructure that is available to scientists 24 hours-a-day These two projects will serve both as experiment and validation platforms and at the same time will provide the Action with realistic inputs of wide distributed platforms usage;
- The OGF-Europe (Open Grid Forum, FP7 RI223784) promotes standards in large scale distributed systems among Europe. Links with this project will give a voice to this Action to a broad spectrum of users, managers and standardization body.

The FP7 projects AIM and the BE-AWARE (answers to the ICT-2007.6.3 ICT call for environmental management and energy efficiency, ICT-224621 and ICT-224557 respectively) investigate complementary approaches with different perspectives. The Action will invite researchers of these projects to participate and/or to give presentations to initiate further collaborations.

Members of the Action include individuals and institutions involved in most of the emerging initiatives on the energy savings topic in Europe, with links existing with similar initiatives worldwide (particularly US and Japan).This will allow for a cross-fertilization of the different research groups and approaches. At the same time, this is an indication that the Action has the critical mass to act as a central point of expertise in the research community.

E.4 Gender balance and involvement of early-stage researchers

This COST Action will respect an appropriate gender balance in all its activities and the Management Committee will place this as a standard item on all its MC agendas. The Action will also be committed to considerably involve early-stage researchers. This item will also be placed as a standard item on all MC agendas.

The participants in the Action will be encouraged to promote the involvement of female professionals in the different activities, and to adhere to gender equality when selecting and/or appointing new members. The Action wants to invite especially female professionals to take an active role at the different levels of management and decision of the Action (MC, WG Chairs, WGSB, FG, DB) in order to achieve gender balance.

The members of this COST Action will be encouraged to promote the participation of early-stage researchers in the different activities of the Action. In particular, they will be encouraged to take an active role in starting and leading new FG.
The short-term exchange of early stage researchers between the participating groups will be a central pillar of the Action, as it permits early-stage researchers to develop lasting contacts.

The Summer Schools for young researchers will build up expertise and help integrate different solutions to the energy savings in distributed systems, as young researches will learn early about different techniques and methodologies. Early-stage researchers will hold the organisation of the Summer schools.

F. TIMETABLE

The total duration of the Action is 4 years. This section details the timescale sketched in section D2. Please note that all the WGs will last until the end of the Action.

WG1 (State of the art and continuous learning of hardware adaptation possibilities) will start with the Action. It will deliver its first deliverable (a reference brochure on hardware possibilities to decrease energy consumption) after 6 months which will be updated every year, meaning at Months6, 18, 30, 42.

WG2 (Characterization of energy consumption and energy efficiency) will start with the Action. It will produce its first deliverable (calibration tools and methodologies to overpass the heterogeneous and dispersed nature of the equipments) at Month 12. The second deliverable (cost models for characterizing energy consumption of different components and of a whole system) will appear at Months 21, 33, 45.

WG3 (Adaptive actions for distributed systems) will start at Month 6. Indeed WG3 needs some inputs from the deliverable of WG1. First results will appear at Month 12 onward so that a large number of results can act as inputs for the WG4 as soon as Month 12.

WG4 (Characterization of performance-energy saving trade-off) will start at Month 12. During its course, it will produce research papers understanding mutual influences of the different approaches investigated by WG3.

WG5 (Scientific coordination and dissemination of the works and definition of a common opened framework) will start with the Action. It will organize the integration workshops and publish their proceedings in cooperation with the Dissemination Board at Month 12, 24, 36, 48. The last integration workshop will serve also as the final meeting of the Action. A book encompassing and gathering the whole experience will be published at this time. WG5 will produce its white paper (defining the basis of the architecture and principles of the common framework) at Month 15, after the first integration workshop. At Months 18, 30, 42, it will deliver results for leaflets and good practices.

WG1, 2, 3 and 4 will produce an annual report of their activities that will serve as basis for the integration workshops.

The MC will meet every 6 Months. It will organize a Summer School every year starting from Year 2. The MC will produce annual reports based on the evaluation of the WGs and their annual reports. The MC will produce the final report of the Action (see details of its actions in section E1 on Organization). Therefore the MC will evaluate and monitor appropriately the achievements of the objectives of the Action in respect with section C.

G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: AT, CY, DE, ES, FR, GR, HU, IE, IT, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 44 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

The Action will dedicate substantial part of the budget for dissemination activities: integration workshop organization and proceedings, website design and construction, publishing of newsletters, leaflets.
The Action will encourage Short-Term Scientific Missions of researchers (especially early-stage researchers), and Summer Schools will be organized, given the budget possibilities.

H. DISSEMINATION PLAN

H.1 Who?

As target audience for project dissemination the Action will address a multitude of groups, exposing scientific results and raising the awareness of eco-friendliness.

1. Academia. In academia there are many research areas that are touched by the Action outcomes. The Grid computing community focuses on efficient usage of vast computing resources, and recently the topic of energy efficiency, for instance leading to the new and important metric FLOP/Watt has attracted lots of attention. Furthermore the Action addresses the whole parallel and distributed computing community, since many Action outcomes will be based on distributed algorithms to be developed within this action. Finally the Action addresses the whole scientific computing community, being the prototypical user group of large scale computing facilities and distributed computing.

2. Industry. As industry target groups the Action, amongst others, addresses IT staff and managers of data and computing centres, which already spend a non-negligible parts of their budgets for buying energy. Second, it addresses computer hardware manufacturers that have focused much on the issue of energy optimized computing hardware. The Action, focusing on distributed optimization, can be seen to be complementary to such local optimization approaches. Finally, it addresses software vendors that will find in the Action innovative algorithms to develop energy efficient software.

3. Energy providers. Providers of energy are addressed as well by this Action. Energy providers could integrate the approach into their energy distribution systems, and influence the power consumption of possibly millions of computers in order to cope with energy load variations in their power grids.

4. Internet Service Providers. ISPs will be interested into the results since they open new business opportunities, connecting computer communication with energy efficiency.

5. General public. The Action specially addresses the general public, since parts of the Action consider energy efficiency in home environments, and investigates how end users can take part in large scale distributed energy efficient computing.

H.2 What?

The Action will use several dissemination methods.

1. Website. The Action will be adequately represented by its own website. The website will display information about the Action itself, members, general information, news around current events, activities and results. The website will also be used as an internal communication tool, for presenting management information, a project Wiki with important data, forms and documents, and publications of the partners. The partners will use this website to create a common knowledge database about the Action topic. It will enable the members to easily communicate with each other and discuss certain topics by using forum and e-mail lists. The forum will also give the possibility to raise a public discussion with people or bodies interested in this topic. The DB will also invite people from bodies related to the ideas of this project to place comments or articles on the website. Links to other websites or events related to the topic will be placed and updated regularly.

2. Newsletter. The Action DB will regularly produce a newsletter on the advances and activities (minute reports, Action status) of the Action. This newsletter will also cover related events and researches. Finally, Short-Term Scientific Missions will be pointed up. This newsletter will be available online and can be printed and distributed to who will leave the address on the website.

3. Technical reports. Once research results are reached, the involved members will create internal technical reports as pre-publication and they will be made available in a restricted section of the website. These reports will timely document the integration efforts and be used as basis for the publication as research papers.

4. Annual reports. The Annual Reports produced by the Action will be regularly published on the website for public access.

5. Research papers. Academic members will publish research papers at important workshops, conferences, and journals. The Action will encourage co-publications between members.

6. Workshop. The Action will organize one integration workshop per year, where research results will be presented. The workshop will be open for other publications from other research groups but also to industry. The workshops will be announced in local newspapers, scientific journals and on the website. Invited speakers with different background (e.g. energy providers, companies, green enthusiasts, environment specialists) related to the topics close to the project will give a talk and will form a round table discussion. Workshop proceedings will be published with ISBN and will be posted on the Action website according to the COST Office policy.

7. Seminars. Members will organize industry seminars where current knowledge and research results are presented to the public, for instance people from software industry, hardware vendors etc. These seminars will be organised together with other departments of universities or with other bodies that are working in or close to the research area.

8. Book. The Action will publish at least one book on the topic of green computing and energy efficiency in IT.

9. Newspaper articles. The members will send articles about their work and research results to newspapers, magazines etc. for dissemination of the topic to the general public.

H.3 How?

Besides the means presented above and their dissemination methods, the Action DB will take particularly into account the actual dissemination of the results by continuously monitoring the popularity and usage level of the website. This evaluation will be discussed and the website modified accordingly.

It is the task of the Action DB to prepare a general dissemination plan that is continuously updated and revised during the Action. The DB makes sure that all dissemination methods are properly addressed and implemented during and after the Action run time. For dissemination activities during the Action runtime, the DB will prepare a general time schedule for each dissemination tool within the first six months of the Action. For instance, there will be a workshop scheduled for each year at a different location, there will be a plan for creating a book that should be finished at the end of the Action, there will be scheduled industry seminars, etc. The DB then makes sure that the necessary steps are taken to implement this schedule, for instance by choosing locations for the workshops, or scheduling meetings for discussing the book.

Dissemination activities that should take place after the Action run time are collected during the first half of the Action and written into a dissemination plan that is constantly updated during the Action time. This dissemination plan is then included into the annual report of the penultimate Action year. The plan must make sure that the members agree to carry out the dissemination within a defined time frame, and that the necessary financial means are available.