

CETRA CASE STUDIES

WP1

Pooling resources for distributed control: the case of Infranet Partners¹

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1. Introduction and methodology

Objective of the present case study is to illustrate an example of innovative organizational form adopted by a group of companies confronting a very uncertain high-tech market environment. As we will try to argument later in this paper, by looking at this case with the analytical lenses of complexity science we are able to draw a number of interesting generalizations in keeping with our theory.

We are focusing on a case of innovative organization in which a particular “partnership-based” organizational form is developed in such a way that it enables the participating actors to deal effectively with a changing environment, maintaining enough flexibility to adapt to changing conditions and, at the same time, pooling resources in order to attempt to influence the direction of change in the market system. Interactions within and outside the partnership also foster product innovation processes.

Methodologically, the case study has been reconstructed mostly from secondary literature, including publications and commercial and marketing literature available online. An interview with one of the partner companies was carried out in 2004.

The paper is structured as follows. In this section, we provide a very brief introduction to the history of the organization, Infranet Partners, while in section 2 we provide a synthetic description of the core technology supported by this organization and of the market system that has developed around it; this should help us understand the roles that Infranet Partners’ member companies perform in the market system, and their position with respect to competitors, customers and partners. In section 3, we briefly describe the member companies and the activities that they carry out, both individually and as a partnership. This should better clarify the ways in which the partnership adds value to the individual companies’ operations. We also focus on some specific projects and activities carried out by the organization, in order to explore how the partnership structure is helping its members confront change in the context of a rapidly evolving - and increasingly boundaryless - business and technological environment. In section 4 we attempt an

¹ The author wishes to thank Paolo Bertossi, Paolo Gurisatti and Luisa Sovieni, who were involved in the collection of much of the material, including the interview, on which this report is based; further, many of the arguments presented in this report have been developed thanks to their contribution.

interpretation of the partnerships' advantages and limitations in light of a complex systems approach to economic analysis.

Founded in 1998 as a partnership among four SMEs, Infranet Partners was officially launched in 1999 - at the annual LonWorld Exhibition in Amsterdam - as a six companies' venture. According to their launch press release, the partnership's main objective was "to grow the market for *Infranet* and *LonWorks*® technology in Europe by exploiting new project opportunities, especially in market sectors where Infranet is not widely used today".

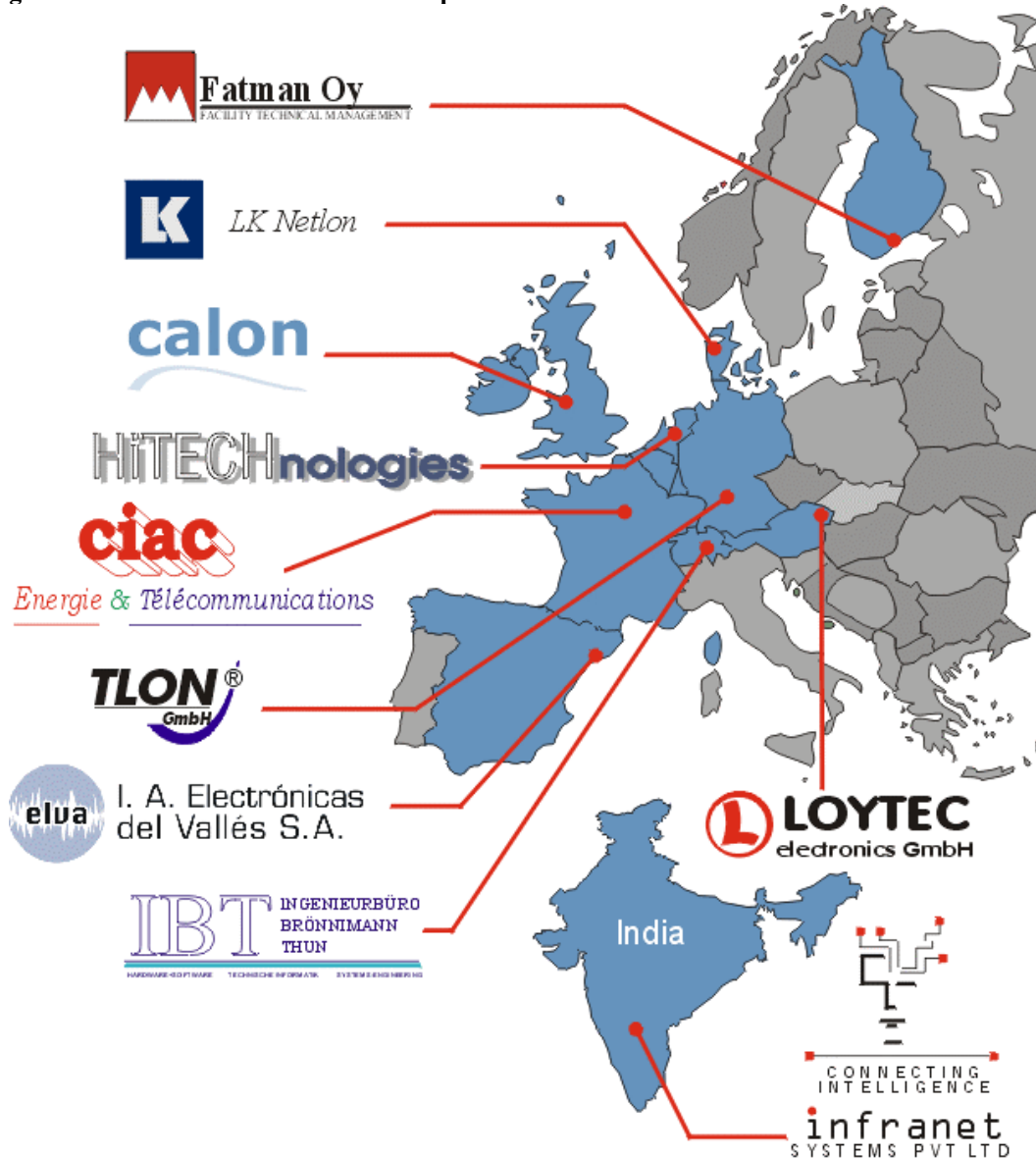
At the time of its public launch, the partnership included TLON GmbH of Germany; Calon Associates Limited of the UK; Netlon of Denmark; HiTECHnologies Industrial Automation BV of the Netherlands; PPA – Systems s.r.o. of Slovakia and ISI Pvt Ltd of India. In the course of the following six years, five new companies joined the partnership while one (PPA Systems of Slovakia) dropped out.

As of 2005, Infranet Partners associates 10 companies in 9 different countries, pooling together the competences of over 70 engineers. The member companies are Fatman Oy (Finland), LK Netlon (Denmark), Calon (UK), TLON (Germany), HiTECHnologies (the Netherlands), CIAC (France), Elva (Spain), IBT (Switzerland), Loytec (Austria) and ISI Pvt (India).

From the corporate viewpoint, Infranet Partners Limited is a company located in the U.K., holding the rights to the Infranet Partners Logo and business concept, while local Partners are financially independent. The total turnover of the group exceeds 10 million €. "By pooling its resources and expertise, it is able to offer project services, training and support across national boundaries in a way that is hard for any one company to do alone. The company produces so many of the products it sells and have most of the products available from stock, therefore it is able to afford attractive prices, flexibility and prompt delivery. Its customers include Bosch, ABB, Shell, DaimlerChrysler, Philips, Cooper Industries"².

² From the website <http://www.buildingopensystems.com/sponsors.php>

Fig. A – Infranet Partners’ member companies in 2005



Source: www.infranet-partners.com

A recent company presentation described Infranet Partners as a “virtual company under a single brand name”, and summarized its main objectives as follows:

- “creating a comprehensive pool of Technology and Application resources
- serving our customers as a single organisation offering locally adapted solutions from this shared pool;
- combining our Product range under the Infranet Partners brand;
- providing a comprehensive product range and support backed by frequent cross training;
- providing a comprehensive Training program across Europe;
- sharing out technical support and knowledge of different markets to provide solutions for our customers;

- sharing marketing information using an advanced dynamic groupware marketing tool to enable us to act faster to meet customer requirements”.

Table 1. Chronology of main events in the partnership’s history

1998	Infranet Partnership is founded by four companies.
1999	Public launch of Infranet Partnership at Echelon's LonWorld99 Exhibition in Amsterdam. The official partnership comprises six SMEs and is chaired by Tim Sly of Calon.
1999	Infranet Partners launch the EU-IST « Dynamic Networked Infranet-Partners (INFRANET) » project, coordinated by Forschungszentrum Infotmatik (FZI), a German research institute.
2002	Infranet Partners take part to the EU-IST « Methodology for the Design of Distributed Embedded Systems (IDESAS) » project, coordinated by Forschungszentrum Infotmatik (FZI).
2001	Infranet Partners exhibit at Hannover Messe
2001	Infranet Partners exhibit at LonWorld 2001, held in Frankfurt
2002	Infranet Partners launch their first LonMark-certified security product (MiniPass®, a compact one-door controller)
2003	Infranet Partners joins the LonMark Interoperability Association
2003	Infranet Partners exhibit at Taltek 2003 in Helsinki
2003	Infranet Partners exhibit at Inteltec 2003 in Switzerland
2005	Infranet Partners launch the Building Open Systems seminar tour, in connection with LonMark International & LonUsers Europe (http://www.buildingopensystems.com)

2. Distributed control networks: a technological innovation of the 1990s

Launched in 1990 by a US-based company called Echelon, LonWorks is a technology for the installation and integration of distributed control networks. This technology has applications in a wide range of projects involving communication among electronic devices – from appliances in the home, to comfort-control systems in a building, to industrial equipment in a factory, and more. Although, at least at the time of its launch, the technology was generally recognized as being far superior to competing “busses” (indeed, 15 years after its launch, the technology is still considered as being a very robust one, which is unusual, to say the least, in the context of rapidly changing ICT technologies) the diffusion has been quite slow and characterized by numerous obstacles.

For our present purposes – and in general from our perspective of economists interested in broad-ranging innovation processes - one of the most interesting characteristics of LonWorks technology is that its successful implementation requires the creation of a new set of agent roles and relationships in the marketplace – in fact, it requires the construction of what Lane and Maxfield (2005) call a *new market system*. When a new family of artifacts, embodying new functionalities, is created, it generally must be accompanied by the creation of a new set of agent roles, relationships and competence networks capable of supporting and reproducing those new functionalities over time. This kind of reciprocally caused social and technological cascades of changes is typical of all situations involving innovation in the space of artifacts,

but it is particularly marked for some technologies which deliver new functionalities to a wide range of socioeconomic domains (let us think, for example, of “general purpose” technologies).

In the case of LonWorks, the main innovation was represented by the introduction of a relatively low-cost microprocessor that could be embedded in a wide range of devices, enabling them to communicate to other devices installed in the same network via a shared communication protocol and operating system. The novelty represented by the chip can be better understood in comparison with the master-slave control networks which preceded it³. The first digital control systems introduced in the 1960s both in building automation (which at the time involved only the automation of the HVAC plant) and in industrial automation, were all dependent on centralized architectures, where the control software would run in a central computer and the individual field nodes would be “dumb” sensors and actuators, simply collecting information from the environment and passing it on to the main computer, or executing commands. The system was quite fragile, because all processes depended on the correct functioning of the central unit; expensive in terms of cabling, because each node had to be wired both to a power source and to the central unit; and rigid, because, once installed, the system configuration could be changed only by changing the wiring. Over time, hierarchical architectures started “flattening”, with the introduction of field control units (PLCs) in charge of a smaller amount of field devices, hence reducing the system’s fragility and rigidity. At the end of the 1980s, “bus” systems were introduced, which allowed for a number of devices to be connected to a local control box through a single “bus” cable, thus reducing cabling costs and simplifying installation; also, control manufacturers started offering a number of possible topologies which allowed greater flexibility of installation (backbone, star, and ring topology).

LonWorks technology, however, took things a step further. The Neuron Chip distributed the intelligence of the system further down, to the level of individual nodes, where each node was able to run control algorithms: sensors could, for instance, collect information from the environment, process it, decide whether action should be taken and if so address it to the appropriate actuator. Nodes, each provided with a unique identification number (NeuronID) could also establish whether messages were addressed to them or to other nodes, in which case they would simply pass them on. The system became more reliable, because the malfunctioning of an individual node would not impair system functionality, less expensive in terms of cabling, and extremely flexible, because the system configuration was logical, not physical. The individual nodes’ “intelligence” allowed for the system topology to be free, and the variety of media available for communication greatly improved the integrator’s choice.

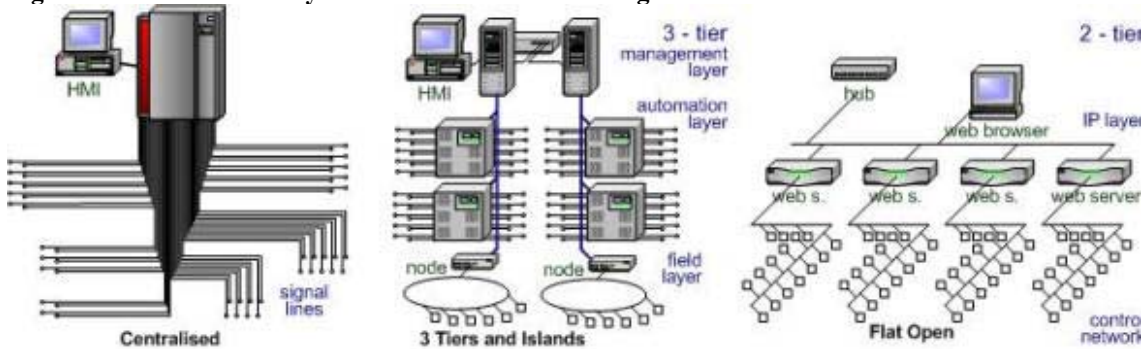
³ For a more detailed description of the history of the creation of a market system for LonWorks technology, see Bertossi, P.; Gurisatti, P.; Rossi, F.; Sovieni, L. (2004) *LonWorks technology in Europe. The creation of a new market system*. ISCOM project research paper; Lane, D. and Maxfield, R. (2003) *The Development of Automated Control and Control Systems to 1990*. ISCOM project research paper

A description of the purely technical features of LonWorks technology and its competitors, however, would not suffice in order to explain the evolution of its market system and the plurality of roles that are being created; we must also take into account the proprietary and procurement structure of the system.

From the start, Echelon envisioned LonWorks-based systems as completely “open” and vendor-independent, a perspective that contrasted with the way in which most control industries worked at the time (and to a lesser extent are still working now). The first digital control systems, whether centralized or more distributed, were generally completely proprietary: control systems manufacturers would sell systems which included control hardware and software tools; the devices communicated through proprietary code and the system could be configured and managed only through expensive proprietary software. Systems could be installed and configured only by the manufacturer itself or by authorized installers, and, once they were installed, the clients were tied to the manufacturer for any system extension or reconfiguration, and even for their maintenance (maintenance contracts were in fact one of the most important and secure sources of revenue for control manufacturers, who would tie customers in with contracts stretching for several years). Proprietary control systems were “closed” systems, because they could not communicate with systems or devices produced by different manufacturers unless endowed with expensive, often custom-made, gateways. This proprietary structure also limited the market for network integration; since integrators had to learn each manufacturer’s tools and code and they had to know how to develop software themselves in order to integrate them. Integrated, multivendor automation projects, where communication was enabled between systems produced by different manufacturers for different applications and the entire system could be supervised and managed through a single tool, were expensive and difficult to implement.

LonWorks-based systems, instead, are “open” because integrators can construct control networks by mixing and matching devices produced by different manufacturers as long as they have been fitted with LonWorks technology. The model proposed by Echelon promotes “device-level interoperability” where all the components that are needed in order to set up and configure a control network can be bought from many competing manufacturers of control devices and of network integration products; once installed, the system can be expanded, reconfigured and maintained by any network integrator that is trained in using LonWorks tools, and the client can decide to add, replace, upgrade nodes in the network without being tied to any specific manufacturer. The successful diffusion of LonWorks technology, therefore, necessarily requires the involvement of a wider set of companies willing to manufacture, sell, integrate, install and maintain LonWorks-based devices and systems.

Fig. B – The evolution of system architecture in building automation



Source: Mason, P. "LonMark International and the LonMark System Interoperability, AutomatedBuildings, July 2004

Despite its suitability for a wide range of applications, LonWorks' degree of penetration in different established market sectors varies widely. It has been quite successful in building automation, where its main competitors in this field are other standard communication protocols like BacNet (originally promoted by the American trade association ASHRAE) and Konnex (promoted by a consortium of European companies spearheaded by Siemens); more and more, convergence among these technologies is made possible by the increasing availability of gateways and other tools allowing for their seamless integration within wider networks. In the industrial world, LonWorks' market penetration is very low due to the presence of established competing communication protocols. The emerging home automation market is still nonexistent, except for one-off installations in luxury homes or for simpler systems based on old standards like X10, although promising developments appear to be taking place in this field. LonWorks has had important applications in the utilities field, with applications in the remote control of electricity meters (the Italian utility Enel installed 27 million LonWorks-controlled meters, a project on a scale that remains unparalleled), of street lights, of vending machines.

Let us now consider the main *types* of companies that are involved in the market system for distributed control networks based on LonWorks technology. The actual companies involved and their modes of interaction vary widely according to the specific applications for which the networks are constructed. For instance, the construction of a LonWorks network for the automation of a building's HVAC and lighting systems entails a completely different set of companies, with different roles and different modes of interaction, than the construction of a LonWorks network for the remote management of a wide set of geographically distributed energy meters. Nonetheless, it is possible to attempt a taxonomy of the main activities performed by the companies involved in the sale, integration, installation and maintenance of LonWorks networks – although, in practice, these roles are often blurred and a company may perform a range or a limited subset of the activities indicated below:

- small producers of “intelligent objects” (often called “network integration products” or NIP): sensors, control modules, actuators; as well as network infrastructure components such as routers, servers, gateways. These products are often very application-specific (smoke or lights control...);

- producers of machines that may or not be integrated in a control network: from HVAC machines to pumps, gas or electricity meters, and so on. In many cases these producers manufacture, among others, a particular line equipped with LonWorks technology, and maybe different lines equipped with other network technologies. For the designing and tuning of these LonWorks-equipped products, a cooperation with a LonWork specialized firm (developer) is always set up;
- small integrated producers (OEM). They produce - or buy and resell - the entire set of artifacts that is needed in order to install a specific control network. They tend to specialize in particular applications – for example, access control systems, lighting systems, fire protection systems, security and so on;
- large integrated control producers (OEM). There are several such firms, most of them with a worldwide market; they produce and install control systems, and produce control devices, machines and plants internally. Some of them, as Johnson Control or Invensys, started as control system producers, others, as Philips, as electrical devices producers, others, as Siemens, started producing both the control systems and the equipment. Most of them have developed their own proprietary code and network architecture. In Europe, with some regional differences, the main big integrated producers sell, in addition to their own proprietary system, LonWorks-based control systems;
- developers. These are independent firms which enable the integration of devices in control networks, in cooperation with the OEMs and, often, with the system integrators that customize the control system. Often, they also produce the software that permits data acquisition and the networking of different objects. It is a role that is typical of open source technologies;
- system integrators. They are the key figures in the implementation of open source control systems. A system integrator designs a control network, and builds it using “Commercial Off The Shelf” components. The system integrator often installs the control system, and manages it, repairs it, and updates it;
- vocational trainers, consultants, installers.

A number of associations have also been created around LonWorks technology, in order to, among other things, support the diffusion of the technology, ensure a supply of products implementing it, guarantee compliance with certain interoperability requirements. Some of the main structures are:

- LonMark Interoperability Association, a worldwide organization which groups mainly producers of LonWorks-compatible devices. Its main aim is to define standardized profiles for specific device categories, compliance to which ensures interoperability among the devices implementing them. LonMark publishes standardized profiles and certifies and tests products' compliance.

- LonUser groups, national organizations of LonWorks technology users. Member companies perform various activities – manufacturing, integration, training and education, software development. The associations' are active in marketing, training and networking. The largest groups are the German and Swedish LonUsers, with over 150 members each.
- Open Systems Alliance, an association of LonWorks-trained network integrators. Admission to OSA is allowed provided that certain requirements are fulfilled on a yearly basis – namely, payment of fees and attendance to a specified number of hours of LonWorks training.
- LID, LonWorks Independent Developers – these are companies which have been granted a keymark by Echelon which identifies them as developers of software products for LonWorks applications.

Understanding the context in which the Infranet Partners consortium and its individual members operate should help us to better understand their activities and their relationships with customers, suppliers, competitors. As it will be clearer from the next section, Infranet Partners' companies generally operate – in terms of the categories outlined above - as small producers of intelligent objects, small OEMs, developers, consultants, trainers, and sometimes as system integrators. Their competencies are often specific to LonWorks and the existence of a market for their products and services sometimes crucially depends on the diffusion and updating - continuous upgrading, increased standardization, expansion in the range of compatible products - of the core technology.

It is not surprising, therefore, to find that Infranet Partners and its members are among the most active companies involved in supporting the technology's diffusion. They do so in many ways, for instance by actively participating to the main marketing programmes and associations of the field –Infranet Partners has been a LonMark member since 2003, and many of its products have been LonMark certified; its members generally take part to their respective national user groups, and some of them have been granted the LID keymark (CIAC, Elva, IBT). The table below summarizes the Infranet Partners members' involvement with the main associations and events dedicated to the promotion of LonWorks technology.

Table B – The partners’ participation to technology-related associations and events

Company Name	Lon Nutzers LNO	LonUsers Sweden	LonUsers UK	LonUsers France	LonUser Austria	LonUsers Italia	LonTech CH	LonUsers Denmark	LonUsers Finland	LonUsers Espana	LonUsers Netherlands	LID	LonMark International	OSA Member	LonWorld Exhibitor 2001	LonWorld Exhibitor 2002	LonWorld Exhibitor 2003	LonWorld Exhibitor 2004
Calon		x															x	
Ciac				x								x	x					
Fatman Oy									x				x					
HITECHnologies													x					
IBT Ing. Brönnimann Thun							x					x	x					
LK Netlon A/S								x					x					
Loytec Electronics GmbH	x				x								x		x	x		x
TLON GmbH		x											x			x		
ELVA										x			x					
Infranet Partners								x					x					x

Many Infranet Partners companies have been involved with the technology since it was first introduced in Europe, and have therefore been able to establish a rich pool of specific engineering competencies. Their experience with the technology allows them to provide training and contribute to the necessary regeneration of competencies in the field, as well as to act as consultants and “troubleshooters” for other companies that wish to implement LonWorks-based products and systems.

The complex structure of the market system – where the successful diffusion of the core technology depends on the joint activities of many different companies engaged with the technology in different ways, and on the regeneration of highly specialized engineering skills – explains some of the advantages to be had by small companies that decide to pool together their resources in order to sustain the creation of a market on whose expansion they found their existence, as we will see in more detail in the next section.

3. The Infranet Partners

After a brief description of each European member of Infranet Partners, we turn to the consortium’s structure and characteristics. Our purpose is to explore some of the advantages – and limitations – offered by the chosen organizational form and investigate how, if at all, it has fostered innovation and change management.

Established in 1997, *Calon* is “the UK's leading supplier of products, services and solutions for intelligent controls based upon LonWorks® and TCP/IP networks”. Their main field of activity is the production and distribution of LonWorks-based hardware and software components, but they also offer complete “plug and play” solutions for specific applications in lighting and energy management, as well as engineering services such as customized product development, technical support and troubleshooting. The company’s Managing Director and Technical manager have been involved with LonWorks technology since it came to Europe in the early nineties, and have “over 35 years of open systems network experience”

between them. Calon's customers, mostly based in UK and Ireland, are OEMs, local authorities, fuel retailers, and system integrators.

CIAC was founded in 1950, and originally specialized in installing heating systems. Over time, it expanded its competencies across a range of different but complementary activities such as climate control, electrical and electronic installations, telecommunications. At present, *CIAC* - which has branches in Poland and Tunisia as well as a network of international distributors - is a designer, integrator and producer specialized in three different fields: communication, energy and environmental technologies. Only the communication branch of *CIAC* is part of Infranet Partners. Here, their main activities are in the fields of security (design, production and installation of access control modules, localization and traceability of people and goods), facility management, remote metering, as well as consulting and training (assistance for product set-up, testing of equipment, maintenance).

ELVA is a Spanish company active in the production of electronic circuits; mostly, they cooperate with OEMs in order to help them design products which incorporate electronic modules (an activity they call "subcontracting") while at the same time they develop their own products, among which a home automation system, access control devices and systems, temperature sensors.

Founded in 1991, *Fatman Oy* is a company whose main activity is the provision of consulting services for facility management and automation-based systems. Thanks to their technical know-how and use of cutting edge computer applications, they have investigated facility management, energy consumption and saving possibilities in over 2000 facilities, mostly commercial, public or industrial. In addition to this, they develop facility management software tools. *Fatman Oy* is also an approved and registered consulting company in EU-projects.

HiTECHnologies, founded in 1987, was the first Dutch company to implement LonWorks technology in 1992, and the first to complete an entirely LonWorks-based building automation project in 1996. *HiTECHnologies* is a manufacturer and integrator of control networks solutions; their main products are powerline controllers, web servers and control modules for access and pump control, while their major engineering competencies are in powerline communication and TCP/IP interconnectivity. In 1998, *HiTECHnologies* opened the first LonWorks Competence Centre.

IBT (Ingenieurbüro Brönnimann Thun) was founded in 1993 by an engineer expert in the field of simulation and multiprocessing application. The company's main activities are the provision of LonWorks engineering services and the production of hardware and software components for LonWorks networks (gateways, I/O modules, room controllers, routers, web servers, interface converters, PC interfaces, etc.).

LK Netlon started as a two-people business in 1995, with the aim of developing solutions for controlling heating, lighting and ventilation systems in buildings; in 1999, the business was incorporated into a joint venture with leading Danish electrical group Lauritz Knudsen, which is part of the global Schneider

Electric company. The company produces a LonWorks-based range of control modules, which are sold in building control applications.

LOYTEC is a provider of LonWorks-based network analysis tools and network infrastructure products for the building automation market – many of which developed thanks to strategic collaborations with other companies. The company also benefits from strong research links with academia. In 2004, Loytec opened their first branch in the US, Loytec Americas.

TLON was founded in 1997 as a spinoff company of THEN Maschinen und Apparatebau GmbH, a manufacturer of machines for the textiles industry. The founder of TLON first got involved with LonWorks technology while working for THEN, when the company developed a LonWorks-based control system for its dyeing machines, and other manufacturers asked them for assistance in switching from their old PLC based systems to LonWorks-based systems. TLON was then founded with the aim to offer hardware and software products and services in connection with LonWorks technology. Today, these still represent the three main branches of TLON's activity: InfraWare (hardware products such as control modules, gateways, protocol analyzers), InfraSoft (software products like software management tools and LNS-based plug-ins), InfraServ (consultancy, advice, project management).

On the one hand, these companies are very heterogeneous from the point of view of their individual histories, their size, and their degree of involvement with LonWorks technology – some only deal with LonWorks applications, for example, while others are competent in a range of different technologies. On the other hand, the companies also present some striking similarities. Many of them perform similar or overlapping activities: they all produce or sell at least one range of hardware and/or software products that can be used in the construction of LonWorks networks, and most of them provide consulting services and training to other companies which need support with the core technology – either in setting up LonWorks-compatible products, or in integrating LonWorks systems. Further, they have all developed LonWorks-specific competencies, and often have been involved with this technology since it first arrived to Europe, in the early nineties. In most cases, the role of specific individuals – generally engineers – who developed a strong professional interest in the technology appears to have been crucial either in the founding of the companies themselves, or in determining the companies' technological choices.

In order to limit the degree of internal competition among partners, the consortium has devised some stringent criteria for admission:

- “partners decided to empower only one partner per country to participate.
- Each partner must bring to the group a specific competence in an area of Infranet technology, or a specific market sector.
- Furthermore, each partner must make a net contribution to the group. This means: each new partner has to bring something new (more sales opportunities, interesting products or technologies, a new market, maybe some cash ...). But he may also bring some products

which directly compete against existing products of the group, he will need training, he needs time to learn the Infranet Partners way of doing business, the Infranet Partners have to change marketing materials (e. g. the map of members) etc. All these are costs. So the Infranet Partners say, (however you measure it) the new partner must make a net positive contribution to the group (what he brings – what he takes out = net positive)”⁴.

In sum, partners’s competencies and activities can overlap to a certain extent, but some steps are taken in order to reduce the probability that two or more members turn out to be direct competitors and, therefore, that a partner’s product or services may cannibalize another partners’ products or services: each company must be located in a different country, thus safeguarding, to a certain extent, its own national market, and partners must have “complementary competencies” so that the broadening of the consortium’s pool of competencies and potential market more than compensates for the risk of cannibalization.

Fig. C – Infranet Partners’criteria for admission

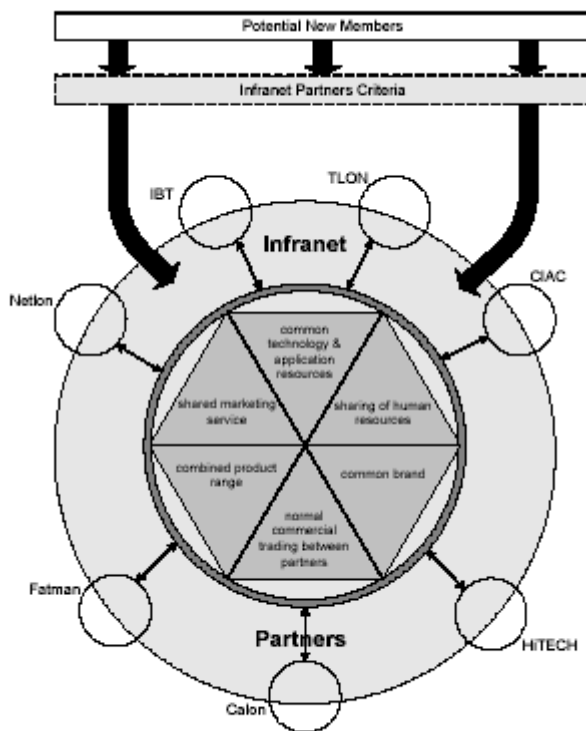


Figure 1: Overview

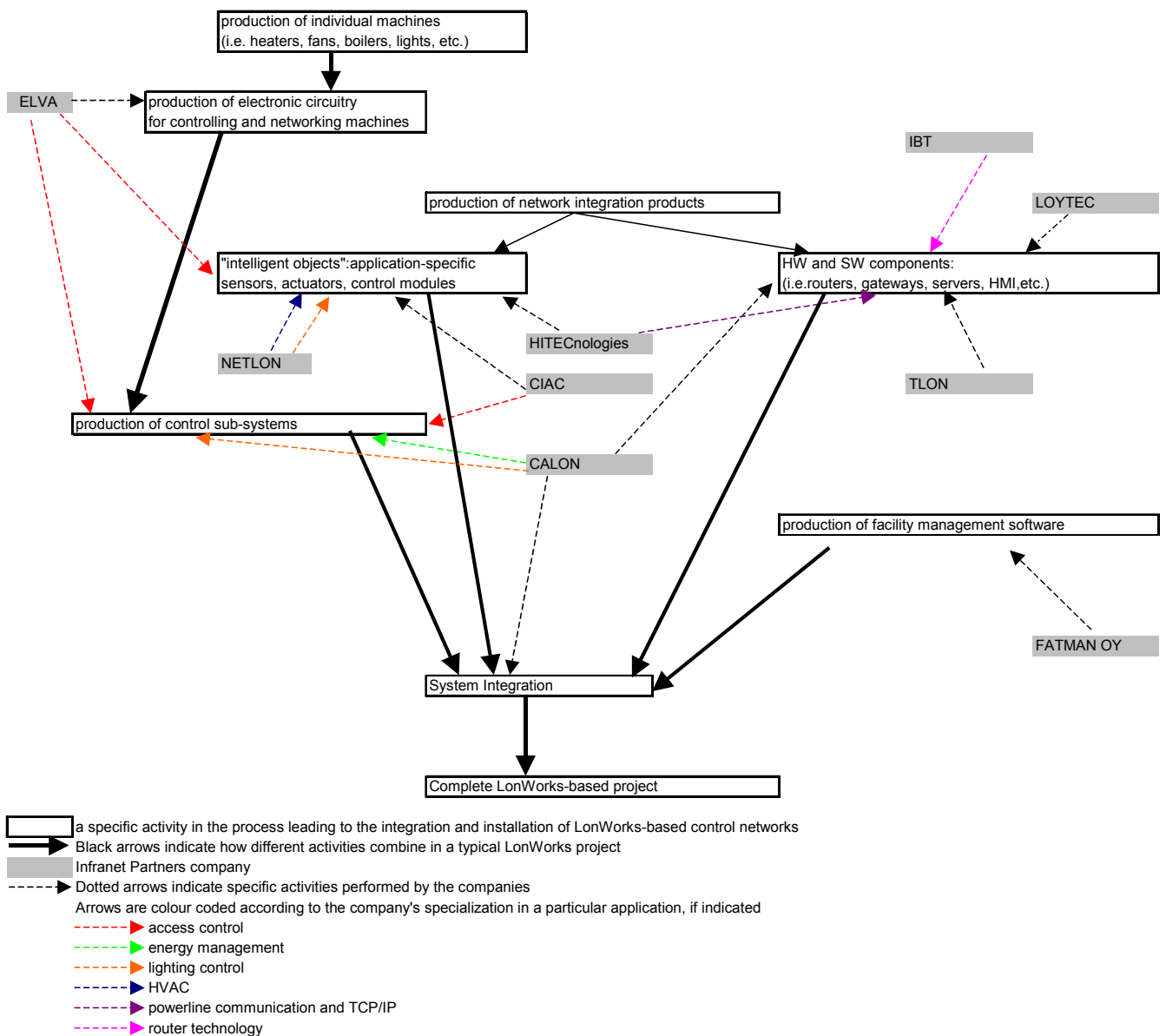
Source: Maedche, A.; Weiss, P. “Towards Ontology-based Smart Organizations”

Figure D below attempts to position Infranet Partners’ companies with respect to the main activities involved in the successful completion of a LonWorks-based project. We can see that the companies’activities are both overlapping and complementary, while each company’s competencies tend to be fairly specialized

⁴ Maedche, A.; Weiss, P. “Towards Ontology-based Smart Organizations”

and different from the other partners'. For sake of simplicity, we have highlighted only those activities involving the production of hardware and software control tools and control systems, and we have omitted from the picture the activities of training and consultancy performed by the individual partners. We must bear in mind, however, that all of them exploit their specific LonWorks competencies by providing training, assistance and advice to other companies involved in the production, installation and integration of LonWorks-based components and systems.

Fig. D – Infranet Partners' competencies



From the organizational viewpoint, Infranet Partners is managed as a “virtual company under a single brand name”, in that individual partners are geographically dispersed, financially independent and free to pursue other ventures with outside partners, as long as they are carried out independently from the Infranet

Partners consortium. The consortium does not have physical headquarters, but the companies' representatives hold regular face-to-face meetings, on the basis of a predefined rota.

The consortium share online resources; in particular, they have a common website which implements an e-commerce tool.

From publicly available information, we have found evidence of numerous partnership agreements between Infranet Partners' members and outside companies, some of which have led to important results. The freedom for members to pursue their own alliances outside the consortium seems to be an important advantage of the chosen, rather informal, organizational form. Some varied examples of external partnerships are the following:

- Loytec have pursued numerous technological partnerships, mostly with larger companies which, presumably, have benefitted from Loytec's specific LonWorks competence and scientific knowledge, whereas Loytec has been able to rely on their partners' greater R&D resources. Together with NEC Electronics, Loytec has developed a high performance, low cost microcontroller for networked devices in building automation; with US company Cimetrics, they have developed a microchip which combines LonWorks and BacNet, the two leading protocols for building automation control networks; with Philips Lighting, they have jointly created a Floor Manager control software based on Loytec's L-Control XP-RTR platform.
- CIAC have signed a cooperation agreement with Israeli company ELPAS, specialised in radio-frequency and infrared technology-based local positioning systems, according to which CIAC will integrate ELPAS' technology in their security and access control product line.
- IBT have collaborated with the the faculty of aerospace Engineering at the Technical University of Delft, The Netherlands, in the development of a flight simulator used in the training of professional pilots.
- In some cases, subsets of Infranet Partners' members have also launched joint projects. One such example is the International Forecourt Interoperability Centre, jointly managed by Calon and HITECHnologies⁵. Having collaborated on the installation of lighting and energy management systems across 600 Shell petrol stations in the UK, Calon, which managed the project, and Hitech, which provided some of the technology, went on to exploit their competencies in this field by jointly creating an "Interoperability Centre". The centre, located in the Netherlands, is run by HITEchnologies and administred by Calon; here, for a fee, forecourt equipment developers "can test their equipment on a LON network with other suppliers of forecourt equipment to prove interoperability in a test environment".

⁵ See: <http://www.ifsf.org/Ioc/documents/iocprocedures2.doc>

- TLON, in particular, pursues a strategy based on actively seeking partnerships with companies which share some of their interests. The company invests a lot of resources in its visibility, mostly through participation to exhibitions, but also through “road shows” – for instance, a joint road show with EBV in 2000, and one in India in 2001 – and membership in associations (FED, Fachverband Elektronik-Design, AMA, OSGI group). They have also formed consortia focused on specific issues – in particular, the “Infranet academy” partnership (with Honeywell, Philips Lighting, SOMFY and TU Dresden) and the “Embedded systems” partnership (with Micrium, Offis, iLogix, Atmel, EBV and FZI) – as well as alliances with individual companies such as Domollum and EBV.

Even a cursory look at these partnerships shows that they have been instrumental in fostering specific product innovation processes. Let us now try to summarize what are the main advantages that the organizational form chosen by Infranet Partners offers to individual members.

First of all, the partnership fosters a mutually beneficial increase in the range of available LonWorks products thanks to the pooling of companies’ catalogues and creation of an “Infranet partners” product range. Each company can presumably access and sell the other companies’ products at favourable prices, therefore offering their customers a wider choice. Each company can also reduce their commercial and logistic costs by sharing distribution channels, including the creation of an “onlines sales” distribution service.

Secondly, each partner can access a wide pool of often complementary competencies around the core LonWorks technology. By relying on the other partners’ competencies, each partner can provide better service and all-rounded support to their existing customers, and increase the *range* and *complexity* of the projects that they are able to bid for.

In the third place, resources can be pooled for activities such as advertising, marketing and networking – thus allowing for a more than proportional increase in each partner’s visibility. For example, by paying just one membership fee, all partners can now participate to the LonMark Interoperability Association. In general, resources can be pooled for joint membership, product certifications, participation to and exhibitions (the partners have been able to exhibit at international fairs, such as LonWorld 2001 and Hanover Messe 2001, something which many of them would not have been able to do individually). The partners can also advertise each other’s products and completed projects, increasing their international visibility.

In the fourth place, the partners can take advantage of their combined set of competencies and experiences by offering comprehensive training in the core technology. Aside from being itself a profitable activity, the offer of up-to-date specialised training is crucial for the expansion and regeneration of LonWorks competencies if the market for the technology is to grow and continue over time.

Finally, and very importantly, the partnership offers individual members increased opportunities for networking and international collaborations, without limiting their freedom to pursue their own projects. For

example, Infranet Partners have already taken part to two European projects, “Infranet Partners”⁶ and “IDESAS”⁷. The kind of connections which allow companies to successfully bid for EU projects, and the administrative resources necessary for their completion, are not often available to small companies. In the case of Infranet Partners, the presence of members with strong links with academia and of another member which had qualified as EU consulting company might have been instrumental in their successful bidding for these projects. In general, the range and quality of contacts available to each individual partner has probably expanded thanks to their participation to the consortium.

At a more general level, as we suggested before, the partnership allows individual members to get together in order to promote a way to create control networks based on distributed open source technologies, in a wide range of applications. Although, as we noted earlier, LonWorks technology is mostly successful in building automation, the Infranet Partners’ competencies span the entire range of its possible applications from building automation (access control, HVAC control, energy management, and so on) to home automation, industrial automation, and more. Interestingly, we can argue that the partners are not interested in supporting LonWorks technology *per se*, but rather the *model* of open source interoperability that this technology affords. In fact, the model of “agent roles” that we presented above (see page 7 and figure D) can be applied to any control technology that shares the characteristics of interoperability and vendor-independence. Infranet Partners are interested in selling products and services for the creation of open source control networks where nodes - whether home or building appliances, energy meters, or industrial plants – are connected on a distributed, peer-to-peer, and vendor-independent basis (so-called “infranet” applications). However, since LonWorks is at present the most reliable and widespread technology which supports this model – and since most technological competencies of the partners are in this field - Infranet Partners are extremely active in promoting it, in the ways that we highlighted above. At the same time, the partners are not tied to this specific technology and should be free to support other “open source” technological solutions should they come along in the future.

4. Conclusions

This particular organization’s history and advantages can be interpreted and generalized in the light of a complex systems approach to economic analysis. Infranet Partners companies operate in a *complex* environment characterized by a very high rate of technological change and strong uncertainty as to what technologies and technological applications will be demanded in the future. While large control companies may be able to fend off this uncertainty by developing a wide portfolio of technological competencies, this option is not open to smaller companies which encounter limits in the amount of resources they can dedicate to R&D and to training. From the point of view of these high-tech specialist SMEs, it makes sense to offer

⁶ EU project “Infranet Partners” – IST-1999-20836 (Dynamic Networked Infranet Partners). The project was coordinated by FZI Forschungszentrum Informatik (Research Center for Information Technologies).

⁷ EU project IDESA – IST-2001-55024 (Methodology for the Design of Distributed Embedded Systems). The project was coordinated by FZI Forschungszentrum Informatik (Research Center for Information Technologies), Dept. of Electronic Systems and Microsystems.

products and services based on a technology that is open, vendor-independent, and not tied to a specific manufacturer's fortunes and whims.

The members of Infranet Partners all appear to have made this choice in the mid to late nineties, when LonWorks technology arrived to Europe and they quickly caught on to its advantages. Their interest in LonWorks and participation to LonWorks user associations and LonMark was instrumental in bringing these companies together in order to form a consortium. These associations, therefore, seem to have performed a "scaffolding" function by supporting the interaction processes which have led to the creation of the consortium. The consortium itself, it can be argued, is a higher-level "scaffolding structure" which sustains the interactions among individual members and allows them to build enough trust and "mutual directedness" to commit to common projects and activities.

The consortium also gives individual partners access to wider *networks of competencies*, and therefore access to more and more complex projects, as well as to types of projects and connections that individual companies may not be able to reach individually. Being able to maintain a wide network of relationships involving different agents at different organizational levels is very important in order to keep many options open, particularly when, as in this case, the market is so uncertain and the pace of technological change so fast that economic agents are unable to form rational expectations about the future market scenarios that will confront them in the future.

At the same time, the consortium's rules are flexible enough that individual partners are free to pursue partnerships and ventures with outside organizations. The partners, in fact, are often specialized in different fields and applications, and may be interested in developing products and services which lie outside the scope of the other companies' interests; from available documentation, we have been able to observe that technological partnerships with companies outside the consortium are indeed quite frequent. Product innovations often result from these collaborations, which may be characterized by a high degree of what Lane and Maxfield (1997) call "*generative potential*". The consortium's flexibility allow them to explore and maintain links outside the technological framework of LonWorks technology, and also contribute to the strategy of "hedging bets" in case of unexpected (and often unpredictable) shocks to the market system.

The present description has been based on a very general investigation of this innovative organizational form. It would be very interesting to increase our understanding of the case through first-hand interviews to the companies involved in setting up the consortium, and particularly it would be interesting to monitor the consortium's evolution over time, in order to study how (and whether) this particular kind of organization is able to adapt to changing market conditions and withstand the challenges from competing technologies and emerging applications.

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