



**SME Exploratory
Award
Proposal**

ESPRIT

Domestic Network Architecture



“Supporting the growth and the spread of the Information Society”

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Part 2: Description of DNA Project

1.1 Technical Summary

1.1.1 Why a Domestic Network Architecture (DNA)

In different ways Bill Gates and Nicholas Negroponte have both given a vision of a home in which all the embedded microprocessors can communicate with each other. Compare this with the current state where we have separate networks for the phone, for TV, for heating controls, for intruder alarm, for computer(s); and none of these different networks talks to each other and none of them talks to the clocks or to 90% of the appliances we have in our homes.

Requirements for a single network include security and privacy, low enough cost to make appliances cheaper if they have the network connection than if they do not, and complete tolerance of untrained users. The network should scale as devices are added, and it should be “green” so that there is no waste of power, of wire, of RFI emissions. For some devices, such as computers and TV, a high data rate is required. Many network technologies exist which are ideal for one or two of these requirements. But all of the existing technologies are also severely deficient in at least one of the other requirements. And particularly in Europe, where most of the spectrum for mains signalling has been reserved for utility companies, the mains provides only a very low data rate and a higher performance network is required.

1.1.2 What

So there is a need for a domestic network architecture which is not best in everything, (except perhaps in being idiot-proof and “green”) but which is good for all the different requirements of the home.

Given the network, as Negroponte suggests, our human interface to appliances becomes voice signals to speech recognisers which then send commands back to the appliance.

1.1.3 How

The exploratory award project will comprise a partner search and a feasibility study.

The partner search will include contact with companies involved in previous “Smart Home” projects, with VESA Home Networks, and with the European Intelligent Building Group, as well as a European partner search under the Eurofit project.

The feasibility study will develop the requirements of the network technology given by industry leaders such as Gates and Negroponte, and benchmark the various candidate technologies by extending the House of Quality analysis shown in this proposal. This analysis will also be used to determine a good Plug&Play architecture, and whether it is necessary to develop one, for example, based on a secure form of Java.

If time and budget permit, the feasibility study will investigate the use of existing speech recognition software to send commands across an existing network interface to an appliance.

1.1.4 Who

The exploratory award is applied for by 4Links for technical help who have contributed to several of the standards for serial interfaces, and who have particular experience with serial interfaces between microprocessor chips such as are in almost all new domestic appliances.

1.2 Objectives

1.2.1 Of the full project

The objective of the full project is to define a standard for home networks in Europe, that can be a single network to encompass all the existing networks for TV, phone, intruder alarm, climate control, and appliance control, which connects to at least one computer and which may also be used to network computers within the home.

The network will not be installed or used unless there is a significant application for its use. A further objective is therefore to show the network used for voice commands to appliances, with the resulting potential for appliance manufacturers of being able to produce appliances without their expensive and ergonomically impossible to design control panels.

Success criteria for the full project are really that a positive-feedback bandwagon develops with manufacturers and users rushing to introduce and to buy appliances and gateways which fit the Domestic Network Architecture. Technical success is if the chips and other infrastructure works, and if appliances are demonstrated. Quality of Life success is if a sample population of elderly or visually impaired people want to use the appliances because it makes their life easier.

1.2.2 Of the feasibility study

The objective of the feasibility study is to establish the requirements for the network and to use the House of Quality tools to see how much change is required from existing practice and hence whether the full project appears feasible. The feasibility study will also aim to demonstrate a very simple example of some of the principles believed to be required of the network, such as a light dimmer, driven across a simple network and responding to spoken commands.

Success of the feasibility study is that the very simple demonstrations work and that they surprise people who find they are unexpectedly easy to use.

1.2.3 Of the proposal preparation

The objective of the proposal preparation is to recruit a group of partners, large enough that the project will have Europe-wide credibility and potential for exploitation, small enough that it is possible to work together as a team.

The objective range of skills of the partners includes manufacturers of kitchen appliances, audio/video equipment and other consumer electronics, domestic climate control, domestic security equipment, software for networking, plug&play, and voice-recognition, together with architects, builders and cable installation companies.

Success of the proposal preparation is that the full proposal is accepted, because the right partners and the right work plans and exploitation plans are detailed in the proposal.

1.2.4 Notes on the objectives

The objectives in some respects look excessively ambitious. Indeed the proposers have the same daunting feeling that one of the pioneers of GSM expressed, when he said that if they'd known when they started how big a job it would be, they'd never have started.

But with leading Americans such as Negroponte and Gates pointing out the need and opportunity for an integrated home network, and with Europe's pre-eminence in communications, there must be scope for such a project in Europe.

While the proposers do not have all the answers for the network architecture, and would not indeed be submitting this proposal if they did, they are at least thoroughly familiar with the requirements of the network, and can point to the features of different existing technologies which need to be synthesised. And while the objectives for speech recognition also seem ambitious, they are actually based on existing software for PCs, available in a limited form at under 100 ECUs, which makes no attempt to be speaker independent and which at any time is only trying to choose between 100 or so possible words or phrases. This software may be found not to be ideal for the application, but its existence proves the objective to be within the possible achievement of the full project.

1.3 Industrial Relevance

The invitation of Nicholas Negroponte to EITC 97 suggests that European industry sees some value in his views.

1.3.1 Our Homes

Negroponte suggests that US has around 100 microprocessors in the home, in all sorts of different gadgets and appliances. Yet how many actually talk to each other? For those that do talk to each other, how many different, incompatible, standard interfaces do they use? We can easily see separate networks for TV, for phone, for intruder alarm, for climate control, quite apart from the several different networks for computers. The more microprocessors we have in our homes, the more it is crazy, costly, and wasteful that it is not possible to connect them with a network that was designed for the purpose of connecting these microprocessors into an integrated home network

Once such a network exists in our homes, so that anything can be added to the network, we can be sure that everything will be added to it and the market for such now undreamed of appliances will bring the number per home nearer to 1000 than 100.

1.3.2 Reduced costs and simpler interfaces

Negroponte shows the effect of combining the network with speech recognition: [Being Digital, p214]

The lack of electronic communication among appliances results in, among other things, very primitive and peculiar interfaces in each. For example as speech becomes the dominant mode of interaction between people and machines, small accessories will also need to talk and listen. However, each one of them can not be expected to have the full means of producing and understanding spoken language. They must communicate and share resources.

So once we have the network and speech recognition in one or two computers (possibly embedded), there is no need to put the complicated control panels onto appliances, saving not only the complexity but also the cost.

In the few cases where something more than speech is required, a control device can be used, perhaps with a touch-screen display so that the legend of each button or slider or dial appear on the display appropriate for the appliance and in context with the current use of the controls. This control device is much more expensive than the phone, though, and so there would be

many fewer such controls around the house than phones or other speech terminals, and as the control device could be a conventional computer, it is left outside the scope of this project.

1.3.3 The market

With close to 100 million homes in Europe, and taking Negroponte's suggested 100 devices per home, this offers a market of 10 billion devices with the network interface in Europe alone. Even if the network is brought down to minimal costs of 1 ECU per device, this is a market of 10 billion ECU. These are of course for existing devices with the network interface. Additional sales of just 10 devices per home at an average price of 20 ECUs (for the device rather than just the interface) brings additional new sales of 20 billion ECU.

A much smaller initial market exists in providing quality of life assistance to the elderly and visually impaired, and there may be good reasons for developing the technology initially for this market.

1.3.4 The competition

The market is sufficiently large that it ought to be addressed by technology designed for the application. Current competing technologies have all been designed for a different purpose.

The two leading contenders are ATM and IEEE 1394 "FireWire".

ATM was designed as a global network and is consequently unnecessarily complicated for the distances and scale of the home. It has already lost out to faster Ethernet in the office market, and anecdotal evidence suggests it is struggling to provide Quality of Service over more than a few switches. ATM Limited, with Cambridge University, have built some impressive demonstration examples of ATM for the home, which serve to demonstrate that switched technology is possible at reasonable cost.

1394 was designed as an improved Appletalk, and is state of the art as a serial bus. The use of a logical bus topology means, however, that the system bandwidth is necessarily less than the cable bandwidth at each node. So if there are 100 nodes, each of them can have on average 1% of the cable bandwidth. The more nodes there are, the more bandwidth is needed and the less is available. The plug&play aspects of 1394 are a significant improvement over existing Hi-Fi and computer spaghetti wiring. But the bus is inherently prone to single point of failure which can isolate whole sections of the bus, which makes it far from idiot-proof. The use of memory addresses means that any node can corrupt any other node, and although each node has a unique ID, the bus presents plenty of scope for spoofing and snooping, thus failing to give either security or privacy. The fact that for the single application of computers, the Wintel standard for 1998 includes both 1394 and USB, which have so much in common between them but yet are incompatible with each other shows that neither is appropriate for the much wider use in the home.

Although a number of points have been made criticising ATM and 1394 in the last two paragraphs, they each have several very strong points for the network. The strong points of these, and of a few other networks, have been collated into the "House of Quality" chart shown as Figure 1. The chart is an initial draft, based on the strong points of the technologies, on the requirements implied by Negroponte and Gates in their books, and on discussions with potential users of the home network (as indeed we all are). The chart needs to be developed further, not only with more Whats and Hows, but with input also from potential partners and a wider collection of potential customers.



Space for picture of House of Quality

In the proposal sent to the Commission, a colour copy was used of a print kindly produced by ASI Quality Services from their demo program which is print disabled. A bit-map of the picture is available zipped in <http://www.walker.demon.co.uk/dnaHQ-0/bitmap.zip>

The demo program itself is available from <http://www.asiqs.co.uk>, and the files produced by the program are :

<http://www.walker.demon.co.uk/dnaHQ-0/homenetz.qf1>

<http://www.walker.demon.co.uk/dnaHQ-0/homenetz.qf2>

<http://www.walker.demon.co.uk/dnaHQ-0/homenetz.qf3>

<http://www.walker.demon.co.uk/dnaHQ-0/homenetz.qf4>

All four files are needed by the program.

For all the limitations of this initial chart, it shows clearly how most of the technologies excel against some requirements but are very poor against other requirements. A genuine solution for the home network will be tolerable against all the diverse requirements, perhaps not being best in as many as the others but never being worst. Targets for such a network are shown by the entries on the chart for “Home Network”.

One of the technologies shown on the “House of Quality” chart is IEEE 1355. This is a switched network designed for short distances between chips, with simpler and more flexible protocols than ATM resulting from the smaller scale of 1355 networks. As with the others, 1355 is not adequate as it stands for the integrated network, but it does have some good characteristics and is not as extreme as the other technologies. In terms of node cost, the basic 1355 circuit is about 600 gates plus a couple of small FIFOs, which is probably less than a 16550 UART. There is actually much in common between the circuit and a UART, and a possible candidate that meets many more of the requirements is one combining “RS232” (in one of its physical manifestations) for the low speed nodes with a derivative of 1355 for the higher speed nodes.

1.4 Outline of envisaged DNA technology

Much of the recent work in networks has been to make the link speed ever faster. Fast connections are required for the home, but many more connections are required for which the speed required is very conservative, even down to a few bytes per second. We therefore try to minimise the change required of these low speed devices, and also to minimise the speed of the signals in the cables.

Most of the consumer appliances with embedded processors use the 8051 or similar microcontroller, and there is a huge variety of these to choose from. Most of them have some sort of serial interface, and the one that seems most commonly available across all the families of these microcontrollers is "RS232". This has advantages that data across it is just a stream of bytes rather than having a built-in memory access protocol, for example, and it is one of the few interfaces which includes a flow-control mechanism so that data does not overflow or under-run. It has a variety of PHYsical layers, including RS232, RS422, RS485, and IrDA, with components readily available for all of these. The IrDA PHY means that these devices can be integrated with a short-distance wireless network. And the asynchronous byte stream means that the wire is idle when there is nothing to transmit, so power can be reduced.

We therefore suggest using the "RS232" byte stream as the basis for the network. Speed currently goes to 4Mbits/s for IrDA, which is fast enough for MPEG1 coded TV, and almost fast enough for MPEG2. The over-sampling principle used by "RS232" was also used by transputer links in 1985 for links running at 20 Mbits/s, with sampling on both edges of a local 50MHz clock. Millions of these links have been used for billions of hours with exceptional reliability. The processor clock on the early transputers was 15MHz, so with modern 1997 processor clocks running at 200 to 500 MHz, a sampling clock should be possible at 1GHz or more. Even using both edges of a 200MHz clock offers 80Mbits/s, which is probably more than is actually needed in the home.

All the recent network technologies, including Ethernet, ATM, FibreChannel, ServerNet and MyriNet, use switching so that the total network throughput can grow as the network grows, and so that paths not used by one packet are available for other packets. A particularly cost-effective switching technology is used in IEEE 1355, which requires no more logic for a port than an RS232 UART. So we suggest combining the over-sampled asynchronous RS232 with the switching protocols of IEEE 1355. Recent additions compatible with 1355 have included multicast and priority routing, which would be particularly useful for the domestic network.

It may be possible to use an existing technology for Plug&Play network initialisation and control. The most open existing P&P system, however, is Sun's Open Boot, which is based on the language FORTH. There is no doubt that if Sun were inventing Open Boot now, they would use Java. There are some problems with Java, however, in its handling of concurrency, which are addressed by the Java class library provided in JavaPP (for Java Plug and Play). JavaPP is not a new language but builds totally compatibly onto the existing language, providing security, scalability, and greatly simplifying the construction of dynamic concurrent software. We suggest therefore that each node on the network contains a JavaPP applet in ROM, and this applet is downloaded by anything that wants to talk to the node.

Several new standards include power distribution with the signals. In the home we are collecting ever more transformers between the mains and the appliances. The network should supply ample power for the house, up to a limit of 10 to 30 watts per appliance, and preferably battery backed (as with most intruder alarms) in case of power failure.

These current suggestions will be validated or revised in the light of the feedback from a user and supplier survey, and from experiments carried out in the feasibility study.

1.5 European Dimension

Europe stands to gain billions in market for its industry, and an improved quality of life for its people.

Until recently, the idea of home networks has been linked to that of signalling on the mains, which in some respects is particularly attractive as so many appliances are already connected to the mains. In the USA, where consumers have been allocated the power-line spectrum between 0 and 340kHz, there are indeed several suppliers of home networking equipment using the mains. In Europe, however, consumers have been allocated the band between 125kHz and 140kHz, with most of the rest reserved for utility companies. This means the quality and data rate that can be used in Europe is much lower than is possible in the USA, and this is why mains signalling was not included in the competitive analysis. So Europe has a much more significant need for an alternative network than the USA.

A presentation on IEEE 1355 and derivatives for home networks was given to Olivetti Personal Computers, who requested a meeting because they could see useful appliances they could make, but which would only have a market if the domestic network existed. They asked for something that might be called a "EuroPlug", which was standard across Europe, and which became as pervasive as the mains sockets in our homes.

Olivetti Personal Computers were keen that the project should include not only the manufacturers of appliances, but also a company, for example, that installs cable in homes. In fact most retrofitted cable is done for intruder alarms, and Europe has a strong independent presence in domestic security equipment and installation.

The European Intelligent Buildings Group (EIBG) has members from all over Europe, and many of their members are potential partners in the full project.

As described above, the most open existing P&P system, Sun's Open Boot, is based on the language FORTH. There is no doubt that if Sun were inventing Open Boot now, they would use Java. There are some problems with Java, however, which are addressed by the Java class library provided in JavaPP (for Java Plug and Play). JavaPP is being developed in Europe, particularly by the universities of Twente and Kent.

While a route to finding some of the potential partners in the project is clear, it is important to find an appropriate fit of partners. So 4Links will participate in a partner search conducted under the Eurofit project.

While the proposal fits under several possible Tasks of the ESPRIT Framework IV programme, the Framework V topic "Creating a User Friendly Information Society" is ideally targeted by this people-friendly network for the home.

1.6 Profile of the Proposer/Co-ordinating Partner

4Links offers boards, chips, IPR and consultancy, for links.

The links are serial interfaces with distance of a few tens of metres, such as is required for the home. Most of this work has been based on IEEE 1355, but 4Links has also contributed to IEEE 1394, and sees that as a good solution for a Personal Computer although not for use beyond what it was designed for.

4Links has provided subcontract consultancy to the Macramé and Arches projects, which have been developing the OMI Heterogeneous InterConnect (HIC) technology that has become IEEE 1355. 4Links has contributed as a subcontractor, but has not been a partner in a European project.

4Links is owned by C P H (Paul) Walker, who will co-ordinate and manage the exploratory award project and will offer to co-ordinate the full project.

1.6.1 Profile of Project Manager

Paul Walker is a technical expert on serial interfaces and on modularity. He has patents applied for or granted in communications, fault-tolerance, memories, and packaging, and has published many papers and articles including in Byte, in IEE Computing and Control, and in IEE Review. He moves between the roles of technical expert, catalyst, promoter, analogy generator^{*}, listener and manager, depending on what the job or the client most has need of. He has a large experience of working with other people and companies in partnership and in subcontract relationships in both directions. While at INMOS, apart from work on the PUMA, GPMIMD, and HIC projects, he devised the TRAM transputer modules which became an industry standard, with sales around \$100M. The group he managed that put TRAMs into the market consisted mostly of new graduates who, using subcontract manufacture, achieved annual turnover per employee exceeding \$700k.

1.6.2 Profile of principal subcontractor

4Links has worked closely with Dr Barry M Cook of Keele University, and will subcontract parts of the feasibility study to Dr Cook. In his work, Dr Cook is an expert on the interaction between hardware and software, having run a student VLSI lab, where the students designed circuits which were built on a multi-project wafer, and having written compilers and device drivers. In his hobbies, his interest in both music and electronics has led to the construction of a wide variety of analog and digital electronics devices in his home, and he is currently constructing a network in his home. This very wide range of skills, combined with his being a user/customer for the technology, makes him outstandingly qualified for contributing to the Domestic Network Architecture.

^{*} The mention of analogies is deliberate. TRAMs turned a less easy to use transputer chip with 84 pins into a very flexible and easy to use component with 16 pins. They became so easy to use they were like LEGO® bricks. The home needs such an easy to use network, except it needs to be even easier and sell in 100s of \$billions. Another analogy is the comparison of communications with modern manufacturing, which has gone through a complete paradigm shift over the last 50 years. Communications share the same goals as a production line, in maximising throughput and quality, minimising cost and delay. But in spite of our recent advances in communications, the latest technology is somewhere between the 1950s and early '80s compared with modern manufacturing. An appendix suggests that one of the candidates network technologies is rather closer to catching up, even if, as suggested in this proposal, it needs further improvement.

1.7 Profiles of partners for full project

The capabilities and products of the ideal partners are shown in the house diagram shown as Figure 2 below, under the headings of Users, Hardware and Software infrastructure, Specifications, Appliances and Gateways to other networks.

The project must include users. While every person involved in the DNA project is a potential user in their own home, there may be an initial low-volume market for the technology in providing quality-of-life improvements for the elderly and visually impaired, and representatives of such people should be included in the project.

Even within the full project it will not be possible to provide examples of all the appliance types or all the gateways listed, but enough different ones should be in the project to demonstrate the range of costs and performances that the network needs to serve.

SMEs and universities will be welcome to participate to offer a single entry in the house diagram of Figure 2. Large companies wishing to be partners should be prepared and able to contribute to at least two different entries in Figure 2, and from at least two different “rooms” or headings in the figure.

Partners making appliances or gateways will be expected to build functional prototype versions with prototype soft macrocells and with prototypes of other infrastructure elements. Experience with using these prototypes and integrating them within the network will be fed back to the specifications and infrastructure designs.

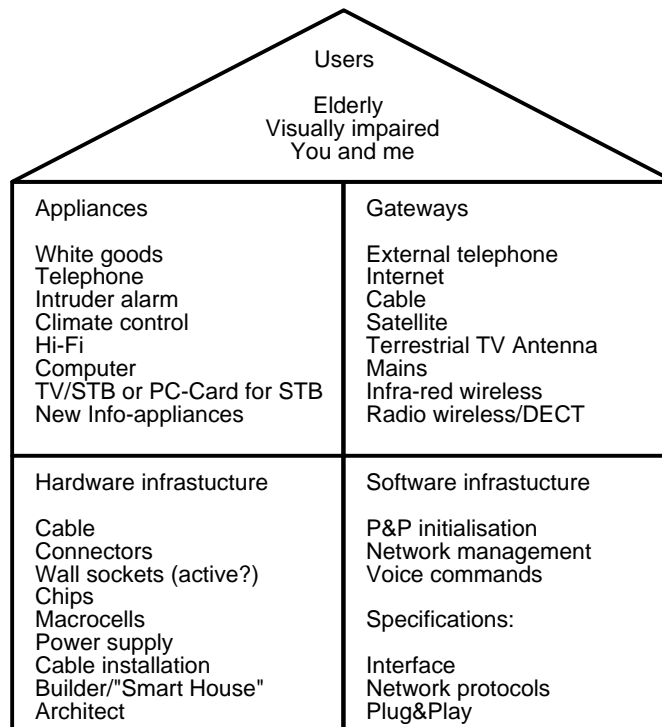


Figure 2: Products and capabilities targeted from DNA partners

1.8 Project Workplan for Exploratory Award

1.8.1 WP 1.1: User/supplier survey and partner search

4Links will conduct a survey, targeting potential partners in the full project, but treating the survey subjects both in their capacity as users of a Domestic Network and as representatives of companies who might contribute to the project and benefit from sales of products for the network. The survey will be based on the “House of Quality” (HoQ) of Figure 1, and the house diagram of Figure 2.

For the HoQ, they will be asked to add requirements (Whats) both for themselves and for their company, to rate the importance of the requirements, to list the competitors they see as most important, and to grade these competitors according to their own perceptions. The survey will be sent out on paper, but with details of how to access the HoQ demo software used, so that if they wish they can construct their own HoQ charts and email these to 4Links.

For Figure 2, they will be asked to correct any omissions they feel are important, and to offer which entries in the figure they are willing and able to contribute to the project.

4Links will take at least one day of training in the House of Quality techniques in order to better prepare the survey questions, and will purchase the full copy of the software rather than use the demo version used for Figure 1. The training is 750 ECU and the software is 625 ECU.

For the partner search, 4Links will join the EIBG, and will offer a talk to them about the possibilities for an integrated home network such as would be produced in the full DNA project. Members would be invited to complete the survey questions and to offer contributions as partners in the project.

The opportunity will be taken to do a partner search under the Eurofit project, including advertising for partners at EMMSEC 97 in Florence.

The survey and partner search will take five man-weeks, spread over the first half of the project.

1.8.2 WP 1.2 Proposal expansion

Individual meetings will be held between 4Links and each of the prospective partners, from which the actual partners will be selected and the sections of the proposal relating to each of the partners will be agreed. 4Links will then collate these sections and complete a first draft of the proposal, which will be sent for comment to all the partners and to an expert consultant.

Feedback from the partners and the expert consultant will be used to produce a second draft of the proposal which will be reviewed at a joint meeting of all the partners. The final proposal will be prepared from the agreements at this meeting.

Travel for the different meetings will vary in cost, but the plan should include 8 meetings at an average travel cost of 600 ECU. The expert consultant’s fee is 2250 ECU, and the meeting cost for the proposal review meeting is 1000 ECU. Manpower for the proposal expansion will be five man-weeks, spread over the second half of the project.

1.8.3 Feasibility studies

1.8.3.1 WP 2.1 and 2.2 Simple Appliance and JavaPP aPplet

It is not possible, within the feasibility study, to build a model appliance. But it might be possible to build a light dimmer, and to drive it from a microprocessor (or 8051) with an RS232 interface to a PC. It may also be possible to include in the 8051's memory a JavaPP aPplet which includes all the methods that can be used to control the light dimmer. The aPplet would not be run on the 8051 but would be downloaded on request to the PC as a Java program that responds to commands from the keyboard. The light dimmer and 8051 is four man-weeks, the aPplet three man-weeks.

1.8.3.2 WP 2.3 Voice Commands

Commercial software exists to generate keyboard commands from voice input. A particular version is In Cube from Command Corp., which makes no attempt to be speaker independent, but trains itself to distinguish between a rather small number of alternative commands that are in context at a particular time. Purchase of the full version of this software is 500 ECU, and using it to generate the commands for the light dimmer is one and a half man-weeks.

1.8.3.3 WP 2.4 Combination of RS232 and IEEE 1355

Keele University, in collaboration with 4Links, have designed a small routing switch for IEEE 1355, with up to eight full-duplex ports. We believe it is possible to:

- include RS232 ports as well as 1355 ports in the switch
- combine the logic for both RS232 and IEEE 1355 so that each port can handle either protocol
- adapt the 1355 physical layer so that it is over-sampled like RS232, certainly up to 20Mbits/s and probably above 50Mbits/s
- further adapt the 1355 physical layer to be capable of being half-duplex and being AC-coupled.

Within the feasibility study, it is not possible to prove all of these. What is possible is to design an RS232 port capable of being used as a port of the switch, and to see how fast this port can be used when looped back to itself. Four man-weeks should be adequate for this, at least as far as simulation of the logic.

1.8.4 WP 3 Management

Two man-weeks is allowed for management functions throughout the exploratory award project, and particularly for management of the subcontractor. With only the one partner, there is not a great scope for disputes within the project. There is plenty of scope for negotiation between the recruited partners, but this is allowed for in the partner search and proposal expansion work packages.

1.9 Outline of Workplan for Full DNA Project

The project will be a three year RTD project with six significant phases, each lasting between six months and a year, but with the phases overlapping.

Phase 1: More complete requirements analysis than will have been possible in the exploratory award, but expanding the House of Quality as a means of focusing questions and of evaluating trade-offs between different potential solutions. The House of Quality can also be used in several phases, with the HOWs of the first chart being used as the WHATs (requirements) of the next phase, and at least one stage of this further analysis will be done with the HoQ.

Phase 2: Infrastructure prototyping with existing components where possible and with the electronics as far as possible in programmable logic and discrete analog circuits. Specifications will be developed in parallel with the infrastructure prototyping, as they need to reflect what is achievable as well as what is required. Software infrastructure will be developed so that something a user can use works very quickly, however little it does, and then more functionality is added to this working and usable basis. It is expected that the use of JavaPP will support this modular, incremental approach. The objective in developing the infrastructure should be to build it quickly, and find the inevitable errors in it while it is still inexpensive and there is time to fix these errors.

Phase 3: Appliance prototyping with the prototype infrastructure designs. Some appliances should be developed immediately the infrastructure components and designs are available and should be tested by real users to feed back to the design of both appliance and infrastructure. These prototypes should be left in a “Smart House” and used by as wide a cross section of users as possible, to give maximum feedback on the use for incorporating into final designs.

Phase 4: The results of phase 3 will be fed back to the infrastructure designs and specifications, and used to create semi-custom silicon components where necessary. This should hopefully not require anything for the slow RS232 circuits, but new developments will be required for routing switch hubs and for higher speed interfaces for microprocessors. There may be a sufficiently general need for integration that a popular core processor is integrated with a small routing switch hub. It is hoped that existing cable and connectors can be used, but there may be advantages in special polarising of connectors for DNA, and it may be useful to make changes to existing products to make them more completely idiot-proof. The software infrastructure should by this stage be solid, with gateways at least via a PC to several of the required gateway interfaces.

Phase 5: A second iteration of the appliance prototypes is made with the semi-custom components of Phase 4. Evaluation of these new prototypes in their environment should be done with the objective of simulating the most untechnical users, to ensure that the appliances and network is proof to them. It may even be worth-while installing equipment in schools, to ensure it survives the ravages of children’s’ play, and it should certainly be installed in a few homes of the elderly and of the visually impaired to validate the expected improvement in Quality of Life for them.

Phase 6: Results of Phase 5 will be fed back to the appliances, infrastructure, and specifications, which will be improved and released for large-scale use. The results of the project will be widely publicised, and everything possible done to promote a bandwagon of exponential growth in the market.

1.10 Duration and Resources

The full DNA project will be substantial, and preparing the full proposal for it will use the full six months allowed under SME Exploratory Awards. Table 1 shows the 26 weeks of the project with the activities and milestones. Each ■ symbol represents half a man-week. 4Links has been collaborating with Dr B M Cook of Keele University and it is expected that activities 2.1, 2.2, and 2.4 will be subcontracted to Dr Cook.

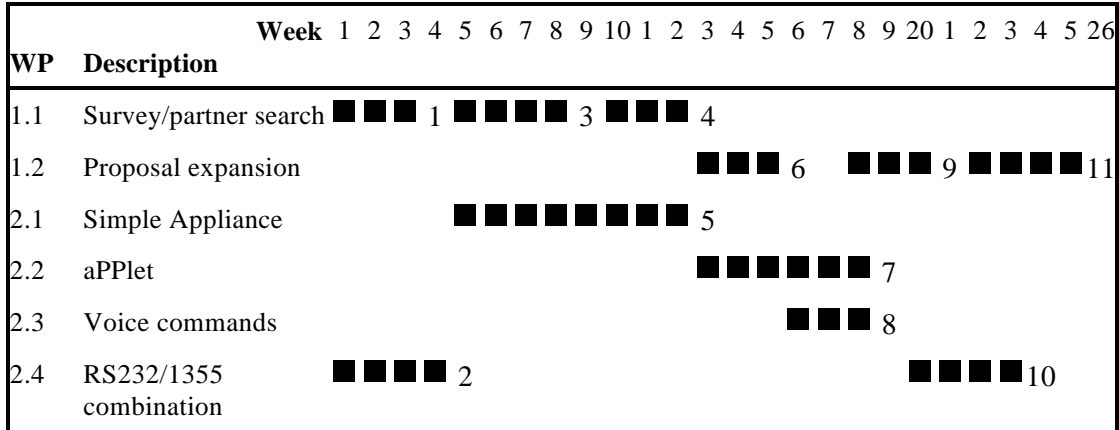


Table 1: Bar chart of activities and milestones

The milestones, including those which are deliverables, are listed in Table 2.

Number	MS/Deliv	When	What	WP	WP Description
1	D	Wk 4	House of Quality Survey sent out	1.1	Survey/search
2		Wk 5	RS232 port for switch, in simulation	1.2	RS232/1355 comb.
3	D	Wk 9	House of Quality Survey results	1.1	Survey/search
4		Wk 13	Partners found	2.1	Survey/search
5		Wk 13	Simple appliance works	1.3	Simple Appliance
6	D	Wk 16	1st draft of full proposal	2.2	Prop. expansion
7		Wk 19	Driver for simple appliance	1.4	aPplet
8	D	Wk 19	Voice commands operate, + report	1.5	Voice commands
9		Wk 21	2nd draft of full proposal	2.2	Prop. expansion
10	D	Wk 24	Speed test report on RS232 port	1.2	RS232/1355 comb.
11	D	Wk 26	Final draft of full proposal	2.2	Prop. expansion

Table 2: Milestones and deliverables

1.10.1 Resource and expenditure summary

The resources of manpower and external expenditure is detailed in the section above on the project workplan. These figures are summarised in Table 3, with labour charged at 2kECU per man-week. The bottom line of the table shows the sums requested at 75% funding, for the feasibility study, the proposal expansion, and for the whole exploratory award project, with all figures within the permissible limits for SME exploratory award projects.

WP	Description	Man-weeks	Labour	Expense	Travel	Feas-study	Proposal prep	Total
1.1	Survey and Partner search	5	10000	1375			11375	11375
1.2	Proposal expansion	5	10000	3250	4800		18050	20050
2.1	Simple Appliance	4	8000	200		8200		8200
2.2	aPPllet	3	6000			6000		6000
2.3	Voice commands	1.5	3000	500		3500		3500
2.4	RS232/1355 combination	4	8000	200		8200		8200
3	Management	2	4000			4000		4000
	Totals	24.5	49000	5525	4800	29900	29425	59325
	At 75% Funding					22330	22160	44490

Table 3: Summary of resources and expenses

Appendix A

This analogy is presented as an appendix as it is not directly in support of the proposal. The Information Package does, however, ask for the impact on industry and society. While no claim can be made that 1355 will have quite the same impact on industry and society as the paradigm shift to modern manufacturing methods, the closeness of the analogy strongly suggests that a very major impact is waiting to be made from communications which model the improvements in manufacturing.

Old production line	Modern manufacturing	IEEE 1355
Bottlenecks	Spare or flexible capacity to eliminate bottlenecks	Multiple paths and adaptive routing to eliminate bottlenecks, provide fault tolerance
Rigid production lines	Flexible manufacturing	Flexible encapsulation of other protocols, flexible network topologies
Quality doesn't matter/repair if faulty	Quality is paramount, Zero defects	Reliable links, buffers never overflow
Don't change it	Continuous improvement	Adding nodes and links continuously improves the network
Lead time is irrelevant	Just-In-Time because delay reduces quality, reduces customer service, and reduces throughput	Worm-hole routing and flow-control minimise delay
Long conveyor belt	Many small, independent, cells	Many independent links
Large batch sizes	Small batches, in trays, preferably one unit per tray	Small packets, appropriate for the application
"Push" components onto the line	When a tray is used, the tray goes back as an order to "pull" more components	Feedback flow-control "pulls" data when there is space for it
Long change-over time	Very fast tool-change	Fast, widely distributed, independent, arbitrations; fast changeover between different packets and protocols
Environment does not matter	Waste of any kind is damaging to the environment (as well as profit)	Eliminate wasted data from buffer overflow, eliminate wasted power driving unnecessary wires, eliminate unnecessary RF pollution
Inventory is asset	Inventory is liability	Minimise data buffers
Make 50% profit margin once per year	Make 20% profit margin 10 times per year	1/5th the link speed in a switched network can offer 20 times the overall throughput of a bus

Table A: Analogies between IEEE 1355 and the recently shifted paradigms in manufacturing