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<p>MOBILE COMMUNICATIONS TECHNOLOGIES FOR YOUNG ADULT LEARNING AND SKILLS DEVELOPMENT (m-Learning) EC Contract Number: IST-2000-25270</p>	

Technology Watch Research Report

Workpackage 8.1

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Task 8.1.1

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1 Introduction

1.1 Background and rationale of this report

1.1.1 The m-Learning project

m-Learning is a 3-year pan-European project which began in October 2001. The project is funded by the European Commission under the Education Area of the Information Society (IST) Programme and is led by the UK's Learning and Skills Development Agency (LSDA). The Consortium is composed of the Consorzio Centro di Ricerca in Matematica Pura ed Applicata (CRMPA) in Italy and Lecando AB in Sweden; project partners in the UK are Cambridge Training and Development Limited (CTAD) and Ultralab, a Learning Technology Research Centre based at Anglia Polytechnic University.

The project began in October 2001 and addresses 3 social/educational problems relating to many young adults aged 16-24 in the EU:

- poor literacy/numeracy;
- non participation in conventional education;
- lack of access creating ICT "haves"/"have-nots".

m-Learning develops prototype products which can re-engage these Target Audiences (TA) in basic skills learning and which can promote life-long learning. Activities are undertaken in 2 phases:

- Phase One: 1 October 2001 - 31 July 2002
- Phase Two: 1 August 2002 - 31 August 2004

1.1.2 Rationale and nature of this report

This report is an outcome of a Technology Watch service undertaken as Task 8.1.1 in Phase 1 for *m-learning* Work Package (WP) 8.1. New and emerging mobile technologies and applications are considered from an *m-learning* perspective, with recommendations for developers. It is beyond the scope of the report to evaluate the technologies at first hand - *caveat emptor!*

Names of products, services and organisations used in the report may be copyright to the producers.

While the rapidly changing state of the market place means that sections of the report were already dated on release, the report nevertheless provides a useful overview of developments and highlights key areas of interest to m-learning: usability, functionality, evolving standards, as well as the expectations of convergence raised by the much-hyped 'always-on' technology. Readers, in particular m-Learning partners, are invited to email alice@ultralab.net with contributions for an updated report in Phase 2.

The report complements findings from other field and desk research undertaken by WPs 7.1 and 8.1. All the findings feed into *m-learning* design and specification tasks in Phase 2, to ensure the *m-learning* products are as accessible to as many young adults as possible.

Executive summary and recommendations are contained in Section 9. A Glossary and Acronyms list are found in the Appendix.

1.2 Method

1.2.1 Search framework

The search framework outlined below is based on the 4-stage approach adopted by the LSDA for WP task 8.1.2. In line with Task 8.1.1 aims and objectives, the framework was used to guide a Web search pertaining to current and emerging mobile technologies, and usage trends. The guide was used flexibly; interesting links were pursued. The Web search was supplemented by information derived from print media, broadcasts, and from the contributions of Ultralab and partner colleagues engaged in relevant research activities.

Stage 1:

A collaborative Technology Watch (TW) database is devised in consultation with interested parties in the *m-learning* partner organisations, defining:

- a basic set of keywords which can be used for initial searching;
- inclusion / exclusion criteria to be applied to the information found;
- indicative sources.

The TW database is made available by Ultralab on the partner pages at *m-learning.org*.

Stage 2:

The searches are led by Ultralab; CTAD and other partners are invited to contribute via the collaborative database. Further keywords are defined as categories and sub-categories emerge.

Stage 3:

The data is then extracted and a preliminary synthesis is undertaken, identifying key areas of interest for the TW report. At this stage Ultralab colleagues undertaking relevant research are invited to provide feedback and additional information.

Stage 4:

In Month 8 TW Report V.1.1 is written up for LSDA and posted on the Ultralab project Web site for comment and input by colleagues. In month 10, V1.2 is made available to Ultralab colleagues for further input; subsequently V1.3 is posted on the partner pages at *m-learning.org*.

1.2.2 Search Criteria

In Stage 1 a number of keywords were identified in discussion with Ultralab colleagues and modified, taking into account the search criteria identified by the LSDA for WP 8.1 on 25/02/2002. The keywords were made available in the TW database on the partner pages of the project Web site for partners' comments and further input.

The narrow and wider search criteria used are listed below; these are based on criteria proposed by LSDA for WP 8.1.

Narrow search criteria:

Range of Equipment Potentially Used	Research Variables
Broadband	None
Handheld	None
Microportal	None
Mobile Internet	None
Mobile phone	None
Palmtop	None
PDA	None
Personal digital assistant	None
Pocket PC	None

Wider search criteria:

(NB: Inclusion/External Criteria apply - see further below)

Range of Equipment Potentially Used	Research Variables
Computer games	None
Notebook computer	None
Telecommunications	None
Portable computer	None
Telematics	None

Inclusion/Exclusion Criteria

The criteria for the inclusion and exclusion of information and literature are similar to those proposed by the LSDA for WP8.1 but with a much narrower search base:

Inclusion Criteria:

Information and literature pertaining to current and emerging mobile personal communications devices and infrastructure and how these might be employed to deliver information services and modules of learning. Only material dated from September 2001 onwards (thus a 1-year search base) is included.

Exclusion Criteria:

All materials not written in the English language are excluded.

1.2.3 Sources of information

In discussion with Ultralab colleagues and project partners, Stage 2 identified indicative sources for the search. In view of the short 'shelf

life' of the information we were looking for, and also mindful of resource constraints (time, funding), it was decided to limit the search mainly to sources readily accessible via the Internet and to direct contact with technology companies through this and other Ultralab projects. Web sites of mobile phone companies were kept under review, e.g.:

- Eriksson: <http://www.ericsson.com/>
- Motorola: <http://www.motorola.com/>
- Nokia: <http://www.nokia.com/>

Other sources were organisations offering products and/or services related to mobile technologies, including information from promotional literature, company white papers and glossaries, e.g.:

- Computerworld: <http://www.computerworld.com/>
- WAP Forum: <http://www.wapforum.org>
- Projectsms: <http://www.projectsms.co.uk/>
- Pogo: <http://www08.pogo.com/>
- BlackBerry: <http://www.blackberry.net/>
- Centrinity: <http://www.softarc.com/>
- Raindance: <http://www.raindance.com/>
- <http://www.mcommercetimes.com/Technology/134>
- <http://www.guardian.co.uk/mobile/>
- <http://news.bbc.co.uk/>

References and an annotated bibliography are found at the end of this report.

1.2.4 Data synthesis

First round of data synthesis:

The main and sub-categories listed on the following page were identified following the first round of data synthesis in Stage 3.

Second round of data synthesis:

Data was further synthesised in Stage 4, resulting in a contents list for presenting the TW Results.

First round of data synthesis

1. Human Computer Interaction - benefits and constraints:
Benefits:
 - Communication
 - FlexibilityConstraints:
 - Size:
 - Data input/output
 - Screen size
 - Memory
 - Purchase & running costs
2. Effects of Industry competition:
 - Mergers
 - Emerging technologies, e.g.:
 - 2.5G and 3G Handsets
 - Smartphones, Communicators, Disposables, Hybrids
3. **Current Mobile technologies:**
 - WAP
 - i-Mode
 - SMS
4. **Current Mobile applications:**
Location-based m-commerce
Games, entertainment (Solitaire, numbers)
Education
5. **Connectivity:**
2.5G, 3G networks
Wireless LANs
Bluetooth
Mobile Virtual Network Operators
Infrastructure sharing:
 - MAST network, coverage, roaming
 - Network jamming, SMS delay
6. **Emerging technologies:**
Chips
Improving user interface
 - Speech recognition
 - Virtual keyboardsMMS
Systems integration
Platforms
Wireless Instant Messaging
7. **Emerging applications:**
Wireless advertising
Wireless e-mail, groupware
Smart Web applications – interactive intelligent programs

2 Networking trends and issues

2.1 Infrastructure, coverage

2.1.1 Internet Protocol (IP)

IP began as a U.S. government project of the Defense, Advanced Research Projects Agency (DARPA) in the 60's. The early DARPA internet, called ARPANET, came into being in the early 70's. IP underpins most communication on the World Wide Web.

IP suite

IP supports a variety of higher-level application protocols, e.g. Transmission Control Protocol (TCP). TCP/IP is the general name given to the IP protocol suite, which includes TCP's relation User Datagram Protocol (UDP), as well as Hypertext Transfer Protocol (HTTP), Simple Mail Transport Protocol (SMTP) and File Transfer Protocol (FTP). Modern operating systems implement support for specific protocols. The following provides an overview:

Application, e.g. HTTP, SMTP, FTP
Transport, e.g. TCP/UDP
Network: IP
Operating System/ Ethernet Device Driver

Protocol 'ports'

IP networking utilises protocol 'ports' at the TCP/UDP transport layer to manage communication channels between programs. Many port numbers are associated with specific applications.

IPv4

Message data travels over an IP-based network in the form of *packets*, each with a header specifying source and destination addresses, etc. Current IP (IPv4) addresses contain four bytes (32 bits); hitherto this was sufficient to address most computers on the Net, however the number of Internet addresses is rapidly escalating; IPv4 users may still experience associated problems, despite solutions such as Classless Inter-Domain Routing (CIDR) and Network Address Translation (NAT) which extend IPv4's potential addresses.

Now the rise of mobile computing means demand for new addresses could soar. IPv6 is a possible solution.

IPv6

IPv6 promises virtually limitless Internet addresses, built-in IPSec security, improved network traffic throughput and service quality. Some vendors don't support IPv6 at all, however Redhat Linux and Solaris 8 & 9 fully support Ipv6.

Ipv6 swings the axis of control of the infrastructure towards common good and public service organisations and is a significant contributor to the EU push for open source and non proprietary software environments.

As will be explained further below, Japan is committed to third generation technology (3G) wireless phones, which need IPv6 for networking, moreover there is a lack of available IPv4 addresses in the Asia-Pacific region, which means Japan leads in deploying the protocol. In the West, wide-spread adoption of IPv6 is still inhibited by:

- lack of wide-scale network infrastructure deployment and lack of 'killer applications' for IPv6
- lack of the range of features which users have with IPv4.

Quality of service is still hard to deliver even with IPv6, because IP is inherently a connectionless protocol not suited to real time data like video and voice.

2.1.2 Network protocols

Network protocols define communication conventions between devices. These protocols include formatting rules for packaging data into messages and may also include conventions like message acknowledgement or data compression to support reliable and/or high-performance communication. Some examples are given below:

Global systems for mobile communications (GSM)

GSM is the dominant cellular technology in Europe. The protocol enables mobile phone users to roam freely, reserving a small portion of the airwaves for your call. Data processing is fast at 9.6 kilobits per second (kbps) but still inefficient because spaces and pauses in speech get the same priority as words, and hence GSM is sometimes referred to as 'Go Slow Mode'.

High Speed Circuit Switched Data (HSCSD)

HSCSD is one of the standards for high-speed data over GSM type of mobile phones. HSCSD establishes a permanent connection to the data network, which makes it suitable for applications such as video-conferencing.

General Packet Radio Service (GPRS)

GPRS is another high speed data technology. However GPRS only lets you download information at between 20kbps and 40kbps, whereas HSCSD delivers speeds of 38.4 to 57.6 Kbps, slightly more than is achievable with a regular fixed telephone system modem.[1]

Universal Mobile Telecommunications System' (UMTS) and Mobile Internet Protocol (Mobile IP)

Previous Internet protocols were not designed for mobile devices; reconfiguration is necessary whenever a mobile host moves, which is time consuming and error prone. UMTS is one of the major new 3G mobile communications systems being developed. UMTS will enable the wireless Information Society, delivering low-cost, high-capacity mobile communications offering data rates as high as 2Mbit/sec under stationary conditions, global roaming and other advanced capabilities.

Mobile IP is a recently developed Internet protocol designed to support the use of mobile devices, enabling the mobile host to stay connected to the Internet regardless of location and without affecting its long-term IP address. The protocol supports security via authentication. Further advantages:

- No physical connection needed: Mobile IP finds and connects to local IP routers automatically and is phone jack and wire free.
- Modifications to other routers and hosts are not required.
- Current IP address and address format stay the same.

Birdstep's open architecture – a 'smart' solution

An example of implementation is Birdstep's Mobile IP, which claims to be a flexible, robust and scalable solution offering seamless roaming between networks including WANs, WLANs, WWANs and WPANs (see 2.1 further below). Its open architecture Mobile IP client lets users and applications connect and reconnect with various network infrastructures with no application downtime or user intervention. Virtual Private Network (VPN) interoperability includes firewall solutions and accommodates security policies, while the client's smart-dial feature automatically dials WAN connections when needed and determines best possible connections at any location. This preferences database can export data in XML format, allowing administrators to set up preconfigured preferences for multiple users.

Authentication options include challenge-response authentication and time-stamp protection. Mobile user authentication is further customisable, based on the user's administrative domain requirements.

Multi platform support includes support for Windows 2000, Pocket PC, and Windows XP platforms, with emerging SymbianOS support.

MosquitoNet Mobile IP

MosquitoNet Mobile IP from Linux [2] is an alternative implementation of the Mobile IP protocol. Enhancements are said to include:

- bi-directional tunnelling for some traffic with triangular routing for others;
- you can turn off mobility support for some flows such as Web browsing traffic.

2.1.3 Cell phones as modems

Nearly 50 million people are expected to use the wireless Internet by 2005, via high-speed wireless networks such as Aerie Networks and via wireless network using the 802.11 standard from companies like Sputnik.[3] UMTS forecasts 2 billion users worldwide by the year 2010.[4] While these are bold statements to make, a growing number of wireless carriers are offering a service for wireless Web-enabled phones, laptops and Personal Digital Assistants (PDA's) to the Internet, enabling cell phone/handhelds to act as modems. In Europe for example, VoiceStream Wireless, a unit of Germany's Deutsche Telekom, has begun offering GPRS to Pocket PC users.

2.1.4 Bandwidth, broadband, wideband

Bandwidth

Bandwidth, the total distance or range between the highest and lowest signals on a transmission channel (band), concerns the speed at which data flows on the channel, expressed as bits per second (bps).

A typical Internet connection has been 56bps or 28.8bps, but even though there is now widespread use of 1Gb Ethernet, capacity may be much slower in practical use owing to hardware factors or computer operating system.

Delays on IP networks can be due to bottleneck when routing the data, or if bandwidth capacity is affected by high latencies (delays in processing network data).

Broadband

Broadband means higher bandwidth, i.e. 2Mbps+, e.g. ATM, XDSL, new types of communication line that can outperform ISDN.

Like the rest of the mobile industry, broadband has suffered from the poor investment climate. Change may come as consumers' interest in mobile games and entertainment leads to video-on-demand from mobile devices, and as businesses' need for a mobile workforce requires flexible access to rich data. Real change would need new business models designed specifically for Internet, as well as convergence protocols, which may be some years hence. While the main limiting factor is cost, the potential benefits for learning are considerable. Currently there is considerable

confusion about the significance of symmetry in bandwidth, particularly for learning. At Ultralab our solid research conclusions from a number of media rich bandwidth hungry projects over a decade is that symmetry is a key component of a broadband learning environment as learners put in and contribute rather than simply download and interact. This skews broadband for learning away from ADSL towards other more symmetrical DSL technologies (VDSL for example).

Broadband Internet

Meanwhile AT&T Broadband Internet is one of a number of U.S. wireless carriers now offering a service for wireless Web -enabled phones. New software and/or a cable is needed to use the services which allow cell phones to connect laptops or personal digital assistants to the Internet.

Wideband

Ultra Wideband (UWB) technology appeared end 2000, promising to deliver:

- hundreds of Mbits/sec of throughput;
- power requirements to link to destinations hundreds of feet away as little as 1/1,000th that of competing technologies such as Bluetooth or 802.11b;
- transceivers small enough to tag small packages;
- traffic interception or even detecting operation of the devices would be nigh impossible; i.e. UWB devices wouldn't interfere with other electromagnetic spectrum users.

While significant deployment of UWB devices may be years away, there are signs that UWB is beginning to fulfil these promises.

UWB vs. spread spectrum

Spread spectrum technologies do artificially what UWB does naturally: array signals across a wide spectrum so that the power concentrated in any particular band is below the threshold where it would interfere with other users of that band, or even be detectable by a narrowband receiver.

Advantages of UWB technology are:

- more efficient transmission power consumption
- less complex electronics power-usage.

However there is a downside; UWB emissions can potentially interfere with many other consumers of the electromagnetic spectrum, and there are serious concerns in the aviation industry about even very low levels of interference. There are also regulatory obstacles.

2.1.5 Network coverage and capacity

Infrastructure sharing and roaming - issues for consumers

Network overload

Service providers compete primarily at customer level, which means a trend towards network infrastructure sharing and roaming across different networks. Developers like it because it means faster speeds, national coverage. However as has just been explained above, the Internet is getting crowded: network infrastructure sharing contributes to network overload, resulting in dropped calls, busy circuits, weak signals - and frequently results in SMS delay as the focus is on voice and synchronous communication.

Problems with roaming

You may need permission to use your mobile abroad - or your phone specification may not be compatible with networks abroad. A 'tri-band' phone is needed to make mobile calls in the US or Canada but there are bigger differences in billing systems between the US and the rest of the world that cause confusion in the users' mind leading to reluctant roamers.

Limitations on spectrum

Service providers tend to focus more on expanding their customer base and on the high-usage subscriber than on improving the coverage and capacity of the existing network, but limitation on spectrum exacerbates poor coverage in some countries.

Spectrum is the range of electromagnetic frequencies at which wireless services are broadcast. Whereas carriers in the U.K. have no caps at all, carriers in Japan and Germany can only use up to 90MHz, to try to ensure that frequencies are spaced far enough apart to prevent overlapping signals. In the United States, each carrier is allocated a maximum of 45MHz of spectrum.

2.1.6 Costs to watch for:

Business tariffs

Mobile network operators regularly change their deals. There may be an additional line rental charge for GPRS services (Internet over GPRS for faster connections), not easily absorbed by small and medium-sized businesses. Benefits in a business account which are not available to people on consumer tariffs include:

- multiple numbers on the same account for easier billing;
- integration with existing landlines allows your callers to get through via an extension number;
- sequential telephone numbering;
- replace and repair arrangements.

Costs to end-users

Competition has brought steady improvement of price/performance ratio of mobile devices - however many mobile phone users are still likely to be paying over the odds. The plethora of different handsets, networks and deals mean that buying a phone to suit your needs and budget can be very difficult - the total cost of ownership exceeds the simple cost of the device. Moreover there is a lack of independent advice on offer to consumers.

End-users should consider:

- cost of text messaging;
- cost of voicemail retrieval;
- penalties for not using the phone;
- cost of monthly line rental may not be worth it;
- network operators can recommend tariffs, but service providers are not obliged to conform to them.

Roaming costs

Roaming is expensive because you are charged for the cost of calls you make and for those you receive, including voicemail messages. Frequent travellers often purchase a mobile phone for the country they travel most to, or purchase another Sim card that they swap when they arrive overseas. However some networks block this initiative.

2.2 Wireless area networks (WANs)

2.2.1 WANs

Mobilinfo has information on Wireless area networks [5] and [6]. Wireless Local Area Networks, allow disparate devices to work together and range from Wide Wireless Area Networks to Wireless Personal Area Networks.

A wireless LAN is a way of linking computers together using radio signals or infrared light instead of cables.

2.2.2 Wireless Local Area Networks (WLANs)

'Hotspots' with WLAN technology

Mobile wireless connection has clear potential in its own right, an industry response to the fixed access market. Conveniently situated Wireless Local Area Networks - 'hotspots' - provide a service for people on the move.

'Hotspots' are wireless devices embedded in public places to provide highspeed connectivity when used in combination with a mobile memory in a laptop or similar mobile device.

An example service:

- *BlueBoard*: a large computer display which is personalised, very fast and simple to use: you can walk up, slide an I.D. card into the device, then the intuitive touch-screen interface with large icons lets you retrieve a range of information from many different sources, e.g. a flight schedule, a personal e-mail and calendar system stored on the Internet, etc.

WLANs may inhibit the success of 3G wireless operators, who need years to put up their networks.

WLAN types range from: infrared, microwave, and radio, with radio further broken down into direct sequence and frequency hopping spread spectrum.

2.2.3 WiFi standards

The US is leading on standards for wireless networking, with the 802.11 series from the Institute of Electrical and Electronics Engineers (IEEE), backed by around 60 vendors supplying more than 200 different products for WLANs. Growth is set to continue thanks to the Wireless Ethernet Compatibility Alliance (WECA), a group of more than 130 companies which provides conformance and interoperability testing and its 'Wi-Fi' label of approval.

Standards in Europe and Japan still trail behind:

- the European Telecommunications Standards Institute (ETSI) has developed HyperLAN/2 for WLANs working at 5GHz the radio band which is used for radar in Europe.
- in Japan the Multimedia Mobile Access Communication (MMAC) Systems Promotion Council group is developing specifications for advanced types of wireless systems, the IEEE is developing additional standards to meet Japanese regulatory guidelines.

2.2.4 WLAN vulnerability

While WLANs promise greater mobility, convenience, improved productivity, current WLAN standards are still vulnerable - network management and security are main concerns. Solutions include Bluesocket's WG-1000 Wireless Gateway, a single-box solution deployed between the WLAN access points and the wired LAN, providing access control, quality of service, and roaming capabilities. Other solutions include Ecutel, ReefEdge and Vernier Networks, which enable seamless roaming between subnets while maintaining quality of service. Care is needed in designing and maintaining the network due to limited available bandwidth (4 - 54 Mb/s depending on the technology) and it is shared between all users.

2.2.5 Synchronisation technologies IRDA and Bluetooth

As will be seen in 4. further below, new convergence devices are appearing alongside discrete mobile devices such as *Pogo* and *Nokia Communicator*. However a call for ever smaller mobile phones on the one hand, and for increased PDA functionality on the other, inhibits their integration as one device, requiring convergence via synchronisation technologies such as IRDA or Bluetooth [7]:

- IRDA - needs line of sight between 2 devices just a few feet apart.
- Bluetooth - no line of sight requirement. Supports multipoint connection between mobile devices as disparate as smart phones, smart pagers, PDAs, handheld PCs and digital copiers, notebooks and printers. Bluetooth's key advantages are low cost and power consumption; already it appears in the new iPAQ Pocket PC and in several brands of mobile phone, enabling their use as a modem. Bluetooth's principal limitation is its range; designed for adjacent devices Bluetooth struggles to deliver "across the room" performance making it a frustratingly "nearly enough" technology to use although range has increased to around 10 metres.

2.2.6 Wireless Personal Area Networks (WPANs)

Synchronisation technologies enable personal connectivity via WPANs (other terms include piconets and scatternets) which allow personal connectivity. They let devices work together, sharing information and services, can be installed within 5-15 metre distances and can even be created via devices such as wireless headsets and microphones. Users customise the communications capabilities.

2.2.7 Educational benefits of ubiquitous computing

Wake Forest University claims the following benefits from its ubiquitous computing with wireless LANs: [15]

- Enhanced collaboration among learners
- More frequent student / staff dialogue
- Prompter feedback
- Better application of theory
- More student initiative
- More personal and individual teaching

Leading to

- Better SAT (standard attainment test) scores and class ranks
- Enhanced retention and graduation rates
- More satisfaction and learning.

Ultralab's wireless research (Learning in the New Millennium project with Nortel 1993 - 2001) found significantly for learning that where learners were physically connected to LAN teachers would describe their students as being "very capable with the technology", but when the learners worked within a wireless environment the teachers simply described them as

being "very capable...". The learner was seen to embody to power of the wireless computer in an unexpected way and this translated into tougher questions and more ambitious tasks being set by the teacher, which in turn led to more rapid progress by the learners. In Ultralab's Edu-Quest wireless and media rich environment project in Singapore (with Apple and the Ministry of Education, 2001-continues) it is also clear that the wireless environment allows a greater integration between discrete curriculum areas (for example science and art).

2.2.8 Alternative connectivity

Temporary or Switched Connection

Permanent connection between mobile user and information source is expensive and often impractical. A popular solution is a temporary wireline connection via dial-up on a public telephone or cellular network. Known as a 'switched' connection, this may be via a switched wireline connection directly between the remote location and the information server - or indirectly through the Internet - via a telephone jack.

Satellite Networks

Network carriers cannot afford base stations in very remote areas, hence the need for wireless networks based on satellites.

Web-native technology

The past decade has seen a move from client/server to web applications, increasing the need to move information in real time between systems, with more systems to connect across the Internet with much less control over most of them. Web-native asynchronous messaging technologies are emerging in response to this new environment: products based on implementations of the Java Messaging Service (JMS) or Web Services specifications, as well as products such as KnowNow's XML Event Routers, that span multiple standards and platforms. Unlike LAN-based messaging products, most web-native messaging products provide:

- *Internet-focused design* –they work cleanly with protocols such as HTTP, can deal with distributed deployments, etc.
- *Ability to connect to browsers* – necessary for connecting the next generation of business applications and to support decentralized administration and operations.
- *Firewall transparency* – webnative messaging products operate easily through firewalls.
- *Application integration* without extensive coding.
- *Support for heterogeneous environments* – applies to people (mixed programmer skills sets), to technologies (mixed protocols, languages, standards and clients), to generations (legacy, client/server, internet, web services), and to architectures (mixed APIs, object models, data models, application tiers, etc.)

- *Support for a broad spectrum of skills* – development and administration teams tend to have a broad range of skills
- *Support for dynamic environments* - messaging in a web-based environment will drive integration of more applications and more users, dynamically, without restart or recompilation.
- *Deployment flexibility* - brokers/routers can be clustered for failover, spread out for scalability, or a combination of both, with support for both volatile and persistent messages, decisions changed during runtime.[9]

2.3 Towards Third Generation mobile telephony (3G)

2.3.1 “2.5G” - an intermediate technology

‘Always-on’, high-speed wireless access

Second generation (2G) technology has been developed into “2.5G” technology such as GPRS, with faster, more convenient data facilities increasingly supported by new mobile devices.

2.5G lets consumers experience ‘always-on’, high-speed wireless access without service providers needing the costly system-wide upgrades required by 3G. At first 2.5G was intended as a stop-gap measure, giving operators time to roll out 3G networks. Then it became a chance for operators to recoup some of their expenses from 3G licence bidding. While many of Europe’s operators have already installed 2.5G technology, a reluctance to announce usage suggests that demand has been poor, possibly because there have been few services for GPRS.[10]

Addressing the shortage of GPRS services

Services are beginning to come onstream which can run on existing Global System for Mobile Communications (GSM) technology but which reach their full potential on GPRS, dealing with larger amounts of data. For example:

- **Motorola suite:** a suite of revenue-generating mobile services that operators can buy in bulk or piece-meal and rebrand as they wish. These data services will run on any handset compliant with current standards. Motorola has already signed up BT’s new wireless business O2, to use the suite’s gaming service.
- **Orange business GPRS service:** allows customers to access their corporate intranets and check their Microsoft email. The service is intended to increase the revenue Orange makes from data, or non-voice calls, with a target of 25% of revenues by 2005.

2.3.2 3G mobile networks: faster access speeds and 'always-on'

Faster access speeds

3G networks are even faster than GPRS, with a maximum limit of 2 mbps per second if you are stationary and 384 kbps while on the move. These speeds allow 3G mobile networks to support many more subscribers who can download data much faster. At peak times however speeds will be much slower and more likely to be around the 56kbps already possible over a fixed phone.

'Always on' via packet data technologies

3G networks promise seamless mobility support, but are built on complex connection-oriented networking infrastructure. They divide each conversation into packets, coding each one to denote which dialogue it is from. The fastest is UMTS; GPRS and IEEE 802.1 are other examples of the new wireless packet data technologies. Use of these technologies means that your phone effectively stays connected to the network, which means for example that local resources and email are always accessible.

Continuous connectivity means brings big changes in the way that you pay for and use your phone, as mobile operators bill you on the basis of the packets you download as opposed to the amount of time online - or make a single monthly charge for everything.

Using 3G services such as I-Mode (see below), your mobile phone becomes a multi-purpose device, for example holding train tickets, discount vouchers or acting as a key to unlock your house. However like WAP, 3G has been over-hyped and in Europe there are spectrum allocation issues and technical difficulties, plus a huge network implementation effort required.

2.3.3 i-Mode

i-Mode

Japan leads on 3G mobile technology with the proprietary *i-Mode* service from Japan's *NTT DoCoMo*, which launched the first full 3G service in October 2001, in the Tokyo region.[11] In Japan, *i-Mode* is fast and efficient, thanks to 'DoPa', DoCoMo's mobile Packet Data Communications system which allows for constant connectivity.

In February 2002 NTT DoCoMo undertook to provide i-Mode technology to E-Plus under a 9-year deal; initially the service uses the GPRS technology fitted by many European operators, but by 2003 most of the major players in Europe could be running on 3G networks.

i-Mode networks are currently being developed in four regions - UK, Germany, Holland and Ireland - over the next five years. (The UK's first public demonstration of 3G services was on the Isle of Man.) Although in Europe the number of non-voice mobile service subscribers is still less

than the number of mobile phone users overall, usage is rising. Non-voice data is predicted to represent 45% of all wireless traffic by end 2002. However these predictions may be optimistic, given the following factors:

- In Japan, *i-Mode* is cheap for the consumer. In Europe however, it won't be if companies decide to recoup from the consumer the huge sums they have expended on UMTS licences.
- In Japan users have access to all kinds of email, m-commerce and entertainment services via around 1,100 official sites appearing on the I-Mode menu - and over 24,000 other sites with no official connection to DoCoMo, which can be viewed via the URL or bookmarked to the phone by e-mail; this is nowhere near the case in Europe.
- In Europe many people commute by car, whereas in Japan most users are commuters via bus and rail (i.e. it is easy to use handhelds), also in Japan there is a lack of PC Internet access so 3G, so-called 'mobile internet', is appealing.

2.4 Emerging networks and services

2.4.1 Hybrid networks

MobileInfo [12] predicts that hybrid networks (co-existence of Bluetooth and 802.11 networks) will enhance (i.e. not replace) 3G via the creation of hybrid networks, where Bluetooth and 802.11 co-exist:

"Bluetooth will become preferred and more affordable method of short-distance connectivity between handheld devices and peripherals as also with drive-in kiosks, wireless ATMs and similar application-specific servers. High-end smart phones in second half of 2002 will be equipped with Bluetooth chips."

2.4.2 Competition for wireless carriers

Mobile Virtual Network Operators (MVNO's)

MVNOs are set to compete against wireless carriers via powerful brands and quality customer service. For example:

- T-Mobile International™ one of Deutsche Telekom's four strategic divisions, has an impressive range of products and services in mobile telecommunications. These cover voice telephony, short message service, fax-data capabilities and Virtual Private Networks, as well as WAP and GPRS wireless data services. With the ultimate goal of offering global mobile communications services, the company already offers services to European and US customers: T-Mobile's transatlantic, single-rate roaming package, known as the "WorldClass" calling plan, enables frequent travellers to use just one mobile number for one rate to access wireless

voice, data and voicemail services - and is set to expand its product portfolio even more. A strength is its bullish market communication strategy worldwide; by end 2002 T-Mobile aims to provide customers of all subsidiaries with more value, more features and more service under a global brand.

- D2, Vodafone's German mobile-phone operation, is a competing MVNO, and has been reporting improved performance.

Faced with this sort of competition, wireless carriers will need to adapt or miss the trend, hence we can expect IP-based networks to strive towards reliability, quality service with high-level security, with simultaneous developments in Broadband and Web Services.

Iburst

In trials in the United States and in the Personal Handyphone network in Japan, ArrayComm's IBurst promises 1 Mbps Internet connection, i.e. 400 times more capacity than current wide-area wireless systems. Targeted at the mass market, IBurst is a portable, wireless Internet system powered by SmartAntenna technology, which it is claimed greatly enhances capacity of wireless spectrum: it adds a unique spatial metric to each transmission, thereby reusing the same channel many times over. [13]

Flash Orthogonal Frequency-Division Multiplexing (Flash OFDM)

Flash OFDM is data-focused, radio router technology that divides a single channel into subchannels, each at a different frequency, boosting bandwidth by letting a system carry several transmissions at once, with a maximum throughput of 1.5 Mbits per second. Flash OFDM minimises interferences, as there is less emphasis on individual channels' quality. Consumers connect with Flash-OFDM networks via PC cards in their notebooks and via flash-memory cards in handheld devices. According to the vendor, it is the first truly IP-based broadband cellular network designed for data, outperforming 3G in all critical areas of performance.

2.4.3 Packet networks vs. radio router systems

Although packet networks such as UMTS increase capacity and spectral efficiency over 2G and 2.5G wireless networks, they still present issues when applied to wireless data. Unlike packetised voice, there is an inherent latency and propagation delay between the sending and receiving software.

Radio-router systems on the other hand are designed to be relatively easy, quick, and economical to implement, as they can be built atop the existing IP infrastructure, rather than from the ground up like a 3G network. They work via a radio-transmission framework for packet-based, broadband, IP wireless communications.

Radio-router technology faces competition from big cellular networks and the big infrastructure investments it needs may not be forthcoming if it

seems too exotic, or if there are too many battles and delays in getting components built to match the new standard.

Market outlook

The market for routers is expected to grow significantly over the next three or four years.[13]

2.5 Towards a global networking infrastructure

2.5.1 Need for end-to-end mobile architecture standards

Competing paradigms

The need to move towards universal interoperability means on the one hand, resolution of competing paradigms: balancing diverse proprietary standards (which stimulate competition) against open standards (which offer universal access). This means merging Next Generation Internet (US federal mission agencies) and Internet 2 (university based, grant aided).

The industry needs end-to-end mobile architecture standards, hitherto, as the GSM Association concedes, competition has inhibited the bringing in of these new technologies.

Nokia's Open Mobile Architecture

According to MobilInfo, Nokia's broader 'Open Mobile Architecture' standard is a big step forward and deserves wide support; unfortunately, not least because of inter-vendor rivalry, this is not likely in the near future.

Handset makers and Microsoft have placed emphasis on proprietary but allegedly 'Open' operating systems like Symbian and Windows-powered Smartphone 2002-based phones, but they are expensive. Nevertheless the next push is towards a global, unified network IP-based infrastructure, to bring increased flexibility – and open standards and support.

2.5.2 Grids

A unified IP network would pave the way for grid computing. The scientific research community already uses grids to link supercomputers into a single virtual machine, with workload managers managing job distribution. Grid protocols are being developed with the goal of creating a standard framework of services and open source distributed operating system to work via the Internet.

2.5.3 The 4G conceptual framework

4G is a conceptual framework for a universal high speed wireless network that will seamlessly interface with wireline backbone network. [14]

Motivation for 4G

4G stems from the ideas of a group of researchers in infrastructure vendors such as: NTT DoCoMo, Ericsson, HP, Motorola, Nokia, Qualcomm, Sun and others who will need a network technology that extends 3G capacity if this proves insufficient to meet needs of future high-performance applications like MMS, multimedia and video applications.

Unresolved bandwidth, coverage and reliability issues are further motivation for developing 4G:

- 3G's multiple standards make it difficult to roam and interoperate across networks; there is a need for global mobility and service portability.
- 3G is primarily a wide-area concept; there is a need for hybrid networks that can utilise wireless LANs as well as cell or base-station wide area network design.
- There is a need for wider bandwidth, and for all-digital packet network capable of utilising full IP with converged voice and data capability.
- The latest modulation schemes are spectrally more efficient but incompatible with 3G infrastructure.

Development in progress

NTT DoCoMo has already started conceptual design of 4G mobile networks, optimistically predicting release by 2010 and 4G data throughput speeds of 100 Mbit/s on downlink and 20 Mbit/s on uplink. This would make 4G 260 times faster than 3G - on past experience however, data transfer rates are more likely to be around a third faster.

4G aims to provide high quality video pictures - double that afforded by standard analogue TV signals. However 4G will require around 100 MHz of bandwidth, so signals bouncing off high buildings will cause problems. DoCoMo claims its OFCDM (Orthogonal Frequency Code Division Multiplexing) technology will reduce this effect.

Prerequisites for 4G

MobileInfo [*ibid*] finds that if 4G is to develop and if implementation is to allow smooth transfer from 3G to 4G, there will need to be the following:

- Phased migration paths, enabling customers to replace or upgrade existing technology at their own pace, for example via upgrading to Voice Over IP (VOIP) in combination with traditional phone services. By next year MobileInfo sees phased migration from 2G to 2.5G and 1xRTT to 3G bringing faster speed, increased capacity (initially by a factor of 3-5) and a marked reduction in wireless data prices (by 50%) but offered on a transaction basis rather than data transfer, and better wireless data deals negotiable to larger enterprises.

- Integration via hybrid networks, to incorporate wireless wide area networks, wireless LANS (IEEE 802.11 standards), Bluetooth as well as broadband wireless networks.
- Inter-vendor cooperation and business models which are voice-independent (unlike voice applications, data applications do not have a built-in demand limit).
- Technology innovations via academic research, particularly in respect of multiband and wideband radios, intelligent antennas and signal processing.
- Standardisation of modulation techniques, switching schemes and roaming will be essential. Spectrum allocation and standardisation decisions will require coordination among spectrum regulators worldwide.

2.6 Interim summary and conclusions for m-learning

2.6.1 Infrastructure, coverage

Importance of IPv6 and Broadband

Users of mobile services may experience network-related delays; these may occur in routing data via the IP suite or where bandwidth capacity is affected by delays in processing network data. High-speed protocols GPRS and new traffic management protocol IPv6 will effect improvements and should reduce SMS delay (important for Target Audiences). IPv6 still lacks 'killer applications' (an opportunity for *m-learning* here) and the range of features users have with IPv4. Quality of service is still hard to deliver even with IPv6, as IP is inherently a connectionless protocol not suited to real time data like video and voice. Important for m-learning: Ipv6 swings the axis of control of the infrastructure towards common good and public service organisations and is a significant contributor to the EU push for open source and non proprietary software environments.

Broadband means higher bandwidth, but has suffered from the poor investment climate. Change may come with video-on-demand and mobile professionals' need for flexible access to rich data; the main limiting factor is cost. Of key interest to m-learning is the significance of symmetry in bandwidth, in Ultralab experience it is a key component of a broadband learning environment as learners put in and contribute rather than simply download and interact. This skews broadband for learning away from ADSL towards other more symmetrical DSL technologies (VDSL for example).

Cost issues:

Relevant to ICT 'have nots' are the new Internet services for wireless Web-enabled phones, laptops and Personal Digital Assistants (PDA's), enabling these to act as modems. However bidding for mobile phone licences has led to spiralling costs and could ultimately make high speed access to the Internet too expensive for ordinary people, thereby widening, not narrowing, the digital divide that *m-Learning* potential users may have to bridge. On past performance however, cost of ownership is likely to come down: m-learning managers should regularly re-negotiate business tariffs.

Roaming will be important for m-learners, not least if they want to widen their scope of peer support and mentoring, but is still problematic. For example: a 'tri-band' phone is needed for some countries and differences in billing systems between the US and the rest of the world can lead to reluctant roamers.

2.6.2 Transportability

A changing network scene brings a need for multi-platform support; network managers must aspire towards seamless interoperability. After software compatibility, security, and network management, managers should investigate the capabilities of different networks for their inherent transportability.

'2.5G' or 3G?

3G promises data rates of 2mbps – however implementation is slow. '2.5G' networks such as EDGE with data rates between 115 kbps and 384 kbps are a good short-term solution and a likely choice for cell phones for the next few years. Developers should keep in touch with broader 'Open Mobile Architectures' and grid computing developments, though these are likely to remain 'niche' technologies for the foreseeable future.

Future networking technologies

4G is being designed to cater for any shortcomings of 3G but implementation depends on a range of factors and is many years hence; eventual implementation is likely via phased migration paths, allowing managers to replace or upgrade existing technology at their own pace, for example via upgrading to Voice Over IP (VOIP) in combination with traditional phone services.

2.6.3 WLANs, messaging middleware

WLANs support real-time access environments via synchronisation technologies such as Bluetooth: 'computer carts' can be wheeled from room to room as needed. Public 'hotspots' or booths offer alternative ubiquitous computing models. Both solutions offer good dial-up connection. Bluetooth's principal limitation is its range (10 metres

maximum); designed for adjacent devices, Bluetooth struggles to deliver 'across the room' performance making it a frustratingly 'nearly enough' technology to use.

Messaging middleware

The legacy messaging solutions that worked for client/server will not adapt to a web-centric model, hence a new generation of messaging solutions. These new technologies are web-native, firewall friendly and easily function with browsers as well as server applications. They promise lower costs and time to market, from web standards. Issues for managers to consider:

- Support for heterogeneous systems.
- Ability to add new topics, filters, transforms, etc dynamically, without requiring an administrator to recompile and redistribute code.
- A true internet-style routing model, so that multiple organisations can manage local user populations without central coordination and can scale both operationally and administratively.

Platform neutral, connecting existing and emerging technologies and resolving Microsoft and J2EE Platform incompatibilities.

Educational benefits and drawbacks:

WLANs and mobile middleware enable mobile device users to download / upload information and applications, with the potential to enhance collaborative learning and facilitate new teaching methods.

The downside: Ultralab's wireless research found significantly that where learners were physically connected to LAN, teachers would describe their students as being "very capable with the technology", but when the learners worked within a wireless environment the teachers simply described them as being "very capable..." The learner was empowered in unexpected ways - this translated into tougher questions and more ambitious tasks being set by the teacher, which in turn led to more rapid progress by the learners. Current Ultralab media rich environment project in Singapore shows that the wireless environment allows a greater integration between discrete curriculum areas (for example science and art).

3. Limitations of mobiles

3.1 Key problems

3.1.2 The devices

Key problems still include small screens with low resolution, limited power and memory, inadequate bandwidth:

- Output: Small (usually monochrome or 2-bit colour) screens displaying only a few lines of text, which restricts the types and amount of information shared.
- Interface: mostly text-based - like first generation Web browsers, but with a very clear move towards MMS and other image and sound based messaging and interfaces. The problem is currently that image based services are perceived as a premium rate activity; those who may benefit most immediately from their adoption are likely to be excluded by pricing in the short term.
- Input: limited to a few buttons or numbers - or by time-consuming handwriting-recognition capabilities.
- Speed: With less processing power (20Mhz) and memory, wireless network connections with less bandwidth (bandwidth is typically 9,600 to 14,400 bps - equivalent to the speed of a modem five years ago) many current devices are slower than computers hard-wired to fast LANs.

3.1.2 The identity debate

The Internet handles identity rather poorly, offering a universal resource locator (url) but no universal person or community locator. New phone technologies offer a very clear personal identity through SIM cards, but little in the way of resource location other than through hybrid approaches like WAP, and no community locator. It is clear that a key battleground in future technologies will be the struggle for control and ownership of the identity servers so crucial to social and learning interaction with Microsoft's Passport and open source solutions (eg Liberty Alliance) lining up head to head.

At Ultralab we are clear from a broad range of on-line community projects (including Schools OnLine with DTI 1995-7, Scoop with Oracle 1998-9, Tesco SchoolNet 2000 1998-2000) that public resolution to this identity problem is a key requirement which is likely to be addressed by a parallel need for identity cards [45]

3.2 Emerging solutions

3.2.1 Specialist solutions

Some of the latest mobile devices are specifically seeking to address input/output limitations of handhelds. Examples of emerging solutions:

Modular solution

IBM Research has developed the MetaPad: a 9-ounce, wallet-size modular PC. MetaPad contains the basics of a PC: a hard drive and memory. Users add modules to convert the device into a handheld, notebook or desktop.

14-line display and full keyboard – the Benefon ESC!

Benefon is a low profile company which concentrates on specialist markets. One of the largest phones on the market, (129x49x23mm) the Benefon ESC! is nevertheless exceptionally light for its size at 174g and comfortable to hold. It has 12-channel GPS receiver and a big screen: 14-line display and full keyboard means emails are easier to read and type.

As the PDA and the cellphone merge small high resolution, daylight viewable, tactile screens become rapidly affordable as economies of scale impact on costs.

3.2.2 Output solutions

Flexible screen

Emerging solutions include a *flexible screen* that plugs into a pocket PC and unfolds like a map.

Magnifying lens

Other solutions keep screens small, but afford good resolution via magnifying lens mounted on monocular units or goggles.

IBM's LCD display

IBM's LCD display improves readability. It looks significantly better than the standard notebook screen: each of the LCD's nine million pixels is designed to appear to the human eye as two pixels - a *tricky pixel*. The tricky display looks good from any angle but at the time of writing is still unavailable for consumer use.

BlueBoard technology

BlueBoard technology is a large computer display designed for public locations such as shopping malls or airport. With large icons and intuitive interface, BlueBoard offers a personalised function, permitting insertion of I.D. card and touch-screen commands to check out both general and specific information.

3.2.3 Input solutions

Split keyboard

The Nokia 5510 has a split keyboard layout designed especially for text messaging and WAP e-mail. (You can also download games and music and listen to FM radio.) <http://www.nokia.com/phones/5510/index.html>

Foldable keyboard

Think Outside has produced a foldable keyboard for PDA's.

Virtual keyboard

Virtual Keyboard, developed by Start-up Virtual Devices is a flashlight-size device for handhelds that projects full-sized keyboard image onto any surface, enabling data input via typing on image. Using cameras, the device tracks finger movement in relation to a keyboard map. Virtual Keyboard could be offered initially as a standalone, although Virtual Devices are in discussion with device makers with a view to incorporating it into handhelds, smart phones and PDAs. The device is planned for release late 2002.

Predictive text

Accelerated text entry software such as Eaton Ergonomics' Eaton's LetterWise and WordWise handle entry of abbreviations, names, addresses, and URLs. [16] They require extremely low processing-power and memory and are already being used in new phones: an in-built memory in the new Nokia 3210 anticipates what you are trying to type and finishes the word for you.

Motion sensors and pattern recognition software

Start-up Senseboard Technologies are developing a keyboard that uses sensors and pattern-recognition software to determine what is being typed. Scurry by Samsung also uses motion sensors.

Speech recognition and speech synthesis

Several cellular-phone manufacturers, including Motorola and Nokia, are trying out speech recognition in the form of simple yes/no responses, or in the form of one-word names of stored phone numbers. In Ultralab's mobile based assessment project (eVIVA with QCA and Orange 2002-2003) the use of speech to text technology is advanced and allows learners to generate a full textual transcript from a lengthy spoken viva using mobile or other digital phones.

Handwriting recognition

Advanced Recognition Technologies (ART) patented technologies bring speech and handwriting recognition solutions designed for mass-market mobile devices, promising:

“fast, accurate response even under the most demanding conditions. With high noise immunity for speech recognition and full natural handwriting recognition even in bumpy conditions, ART's award-winning and market-proven technologies ensure user satisfaction for the full range of cellular handhelds and smart phones (CDMA, TDMA, GSM, G3), mobile communicators, PDA's and automotive systems.” artcomp.com [17]

With most major OSs offering pen based user input from Autumn 2002 it is clear that pen handwriting recognition is set to be supported by a broad

range of "tablet" type personal computers. Unfortunately, for many of the devices, the handwriting / keyboard input option is modal rather than parallel.

Digital pen and paper

Anoto functionality [18] (based on a combination of Adobe Portable Document Format (PDF) and Adobe Acrobat software.) lets you store whatever you write or draw with the *Anoto* tools (specially imprinted paper and a camera pen) directly in your PC, or send it via your mobile phone to any PC, mobile phone or information bank in the world.

E-Ink

Using E Ink's electronic ink technology in TOPPAN's components, Philips is planning to introduce monochrome displays for handheld devices. These 'paper-like' displays promise readability under all lighting conditions including bright sunlight. The next generation will be colour displays to be viewed or illuminated from any angle without loss of contrast and brightness and requiring much less power than current displays.

3.2.4 Speed: new chip solutions

Companies such as Intel and IBM have announced chip advances that are set to significantly accelerate computing processes, indicating that keeping technology moving apace is the only way to escape recession. Moreover fast throughput is essential to make broadband workable.

Small and lightweight, the new chips are helping to overcome limitations of memory and processing power through a balance between the mobile device and nearby embedded resources. The latest chips combine low power consumption with the power to download adaptive software on demand:

Xeon server chip

Intel's new Pentium 4 Xeon server chip will eventually deliver speeds of up to 10 GHz via 'hyper-threading' (simultaneous multi-threading). Xeon will be the first commercially available chip to use this process, which makes one processor appear like two chips to the computer OS, significantly speeding up response time.

Xscale chipsets

Intel's new chipsets *XScale* will process data on cell phones as well as high-end servers, and promise to triple performance over current products. *XScale* technology handles network traffic via a series of integrated processors on a single chip: LAN, WAN, USB 2.0 plus voice compression, thereby significantly increasing performance. The new IOP321 chip supports the new PCI-X bus, making gigabit Ethernet feasible by doubling bus speed and bandwidth, enabling much more efficient data throughput.

Silicon Germanium technology

With its *SiGe* (Silicon Germanium - as opposed to only Silicon, as used by most commercially available chips) technology. IBM Microelectronics claims to have produced 'the world's fastest microchip' with a speed of 110 Ghz. Although usable solely as a communications processor (i.e. moving, not processing, data) it is twice as fast as current chips and should significantly increase the speed of general network communications. The new 110 GHz technology should also filter down from routers to cell phones. IBM licensed 2.5 and 3G chip designs from the UK's TTPCom to produce with *SiGe* .

Dual chipset

Qualcomm's dual *W-CDMA/GSM* chipset, MSM6200, aimed at handset manufacturers, also has GSM capability.

Gallium arsenide chipset

Motorola has developed a computer chip incorporating gallium arsenide that it claims transmits signals up to 35 times faster than is usual. The new chip also handles more functions, thereby eliminating the speed loss and power consumption that results from driving signals chip to chip.

3.3 Interim summary and conclusions for m-learning

3.3.1 The constraints of handhelds

Desktop applications are usually unsuitable for wireless handheld devices; smart phones can't display large colour graphics or support point-and-click navigation although there is a very clear move towards MMS and other image and sound based messaging and interfaces. The problem is currently that image based services are perceived as a premium rate activity; those who may benefit most immediately from their adoption are likely to be excluded by pricing in the short term.

Developers may need to rewrite applications to accommodate these constraints, e.g. design for a small, low-resolution screen with a single window. At the same time we should be ambitious for the future and plan for MMS and also for integration of speech recognition further down the track.

3.3.2 Improvements to user interface

As the PDA and the cellphone merge, small high resolution, daylight viewable, tactile screens become rapidly affordable as economies of scale impact on costs. New chips afford higher access speeds.

Emerging solutions for data entry include integrated keyboards such as those offered by Handspring and Blackberry and pen handwriting recognition, set to be supported by a broad range of "tablet" type personal

computers. Unfortunately, for many of the devices, the handwriting / keyboard input option is modal rather than parallel. Though implementation is likely to remain slow, the use of speech recognition is of great interest: in Ultralab's mobile based assessment project, advanced use of speech to text technology allows learners to generate a full textual transcript from a lengthy spoken viva using mobile or other digital phones.

3.3.3 The identity debate

The Internet handles identity rather poorly: a key battleground in future technologies will be the struggle for control and ownership of the identity servers so crucial to social and learning interaction with Microsoft's Passport and open source solutions (eg Liberty Alliance) lining up head to head.

At Ultralab we are clear from a broad range of on-line community projects that public resolution to this identity problem is a key requirement that is likely to be addressed by a parallel need for identity cards.

4. Programming issues

4.1 Evolving standards

4.1.1 Wireless Application Protocol (WAP)

A de facto standard

With different devices running on competing operating systems and over a variety of wireless network architectures, there is a longstanding need for a common programming environment. A standardisation effort by the Wireless Application Protocol Forum Ltd, and geared to the devices it is being ported to, WAP has worked as a *de facto* standard for delivering wireless data on smart phones and other mobile devices.

Hope and hype

Tremendous hype built around WAP during 1999 and 2000 brought the dream of 'mobile internet', i.e. the convergence of the Internet and the mobile phone. However WAP was not really tuned for the phone and users increasingly perceived a gap between WAP's promises and delivery. This perception, together with thumb cramps and eyestrain from browsing the Web on mobile phones, made many consumers disenchanted with the so-called 'mobile Internet'.

WAP 2.0

User experience of WAP is set to change as new mobile devices offer better input and output solutions. At the same time the industry is undergoing immense transformation, from being technology-led by the

telecommunications sector to one that is consumer-centric: the 'push' technology of WAP 2.0 (just like SMS) opens up new opportunities for m-learning applications developers.

Jataayu Software has released a beta version of WAP 2.0 compliant jBrowser for PocketPC devices. The software is suitable for ARM and SH3 processor based PocketPC devices. [20]

XHTML is the new mark-up language for WAP. It is a hybrid of extensible markup language (XML) and hypertext mark-up language (HTML); while both standardise the way information is presented to be platform independent, XML allows its tags to be customised and defined by the applications using them and has been a cornerstone of Web Services (see Section 6.4 further below).

The World Wide Web Consortium (W3C) have recommended XHTML as the standard for domestic devices and digital TV, which holds out the potential for interoperability between a variety of domestic, business and personal devices.

WAP features and usage

XHTML affords access to WAP sites with colourful graphics and pop-up menus. Cell phone carriers have upgraded their networks, affording faster connection times, plus an 'always-on' aspect which means consumers won't have to pay per-minute to receive WAP content.

WAP offers many convenient features: you can check weather, stocks, flight status, etc. However there is still a lack of content that might attract youth audiences, who are more interested in social content and entertainment.

If so far usage has been disappointing, these online chat entries offer some further explanation:

"... this may be more from ignorance and lack of need tshan (sic) a decision not to use the features. Most consumers and many carrier vendor's sales people do not know what the phones will do beyond e-mail and never even try the services, nor have the desire for the services."

"WAP is fine for a few limited applications, but the user experience in that tiny little screen is very limiting. Even reading EMail is a pain given the small screen. Most people I know that have tried a Web enabled phone have turned off the Web option and now just use it as a phone because the user experience is not enjoyable."

4.1.2 Some other programming standards

Voice XML

Voice XML [21] lets you convert an existing XHTML document into speech. Voice XML elements include:

- synthesised speech;
- digitised audio;
- sound recognition;
- telephone keytone recognition;
- recording sounds, etc.

Using VoiceXML, you can create voice-activated menus, forms, and many more applications, which can contain as much information as you like - and it's all audible.

Voice XML helps you chat to a computer with your phone. There is massive learning potential with this, as well as being a very accessibility friendly way to communicate with a machine.

Handheld device markup language (HDML)

HDML allows you to make your Web site accessible via mobile devices such as phones and pagers. It is the only language that older phones understand but is on its way to obsolescence.

Wireless markup language (WML)

WML, a fully XML-compliant descendant of HDML, is part of the WAP standard. Developed after HDML, it is more elegant and is supported by all new wireless phones.[22]

Microsoft .NET – wireless version

The new version makes it easier for developers to write Windows-based Web Services software for wireless devices.

4.1.3 Competing for first place

Symbian

Symbian Development for Visual Basic Developers AppForge MobileVB development software integrates directly into Microsoft Visual Basic, enabling developers to write multi-platform applications using the Visual Basic development language debugging tools.

Simple Object Access Protocol (SOAP)

SOAP is a protocol specification that uses XML and HTTP as a method invocation mechanism on servers, services, components and objects. Develop.com has frequently asked questions.

Binary Runtime Environment for Wireless (Brew)

Qualcomm's latest version of BREW is a strong contender as the preferred platform for mobile applications. BREW benefits from a built-in data/application delivery system and a deal with Oracle to help mobilise its database applications. Verison is bringing out BREW phones with new file sharing software that enables cell phone users to exchange photos as well as excel and word documents.

Java 2 Micro Edition (J2ME)

The J2ME Platform implements Java support for various consumer and embedded devices such as mobile phones and PDAs, etc. Sun Microsystems is fighting back against BREW, collaborating on a new release of Java for cell phones. Micro Java Network has a list of Java enabled devices.

Competing freeware

BlueMoon 3.0 is an example of competing freeware:

"Write mobile applications once and run them anywhere. Forget WML, HDML, HTML, and VoiceXML. Use the BlueMoon Wireless Application Server and GUI development tool to create enterprise-ready applications that work on any device over any network. With an XML-based language, extensive API, and plenty of sample applications and templates, BlueMoon will help you quickly and efficiently wirelessly extend your business or enterprise." [23]

4.2 Designing for embedded platforms

4.2.1 Issues for new developers

2.5G and 3G wireless systems support multimedia capabilities and also applications common to PDAs. Most wireless applications developers however will be drawn from PC environments and will be unused to the new types of embedded platforms. There is a need for improvisation, given a scarcity of support tools for embedded systems. Some free mobile application development training and tool kits are available on the internet, for example XcelleNet has a free 10-user licence. [24]

Differences which new developers need to be aware of include media transmission rates (narrow data bandwidth compared with wired networks), limited memory resources, and user interface constraints.

Developers should seek to accommodate these in the following ways:

- see what can be offloaded to the network;
- return control to the OS to keep power consumption low;
- adapt code and program data requirements; partition code to gain maximum performance;

- avoid memory leaks - track allocation of dynamic memory;
- accommodate recursive functions and other procedures that push stacks to large sizes;
- design for a small, low-resolution screen with a single window.

4.2.2 Choice of devices and functionality

Issues affecting choice

Choice depends on whether the intention is to keep it simple, with say, an SMS approach - or whether to opt for multi-functional devices. There are cost issues; these are flagged below. There are also learning issues which affect this choice and these are considered in Section 10 further below.

Running costs, licence price, purchase costs:

With more bandwidth to transfer data, handsets are turning into 'microbrowsers', capable of dealing with the Web, receiving and sending e-mail, and acting more like personal digital assistants. However running costs and software licence price for these devices can be high, which makes them less interesting to the *m-learning* market. On past performance however, purchase costs for devices are likely to come down.

Cost to the user of multimedia applications:

While 3G phones will be able to receive colour video transmissions and high-quality music, users may find large files too costly to download. A solution would be to offer short video/audio clips of 10 to 15 seconds as previews, so that people can purchase the full product to download at home through their PC or TV.

4.3 Interim summary and conclusions for m-learning

4.3.1 Evolving protocols

Long accepted as a de facto standard, WAP was over-hyped and users were disenchanted with the so-called 'mobile internet'. User experience is set to change with consumer-centric 'push' technologies, but WAP's future is uncertain; it is now one of several competing standards that continue to evolve. XML, Java and freeware are among alternatives of strong interest to programmers.

4.3.2 Using 2.5G and 3G – designing for embedded systems

2.5G and 3G wireless systems support multimedia capabilities and also applications common to PDAs. A phased migration towards 3G is recommended. However most wireless applications developers however will be drawn from PC environments and will be unused to the new types of embedded platforms.

Designing for embedded systems means catering for different media transmission rates, limited processing power - narrow data bandwidth compared with wired networks. Developers are advised to improvise, for example where possible offload to the network and return control to the OS to keep power consumption low. Free toolkits are available via the internet, for example XcelleNet has a free 10-user licence.

3G phones will be able to receive colour video transmissions and high-quality music, however users may find large files too costly to download. A solution is to offer short video/audio clips of 10 to 15 seconds as previews, encouraging people to download the full product at home through their PC or TV.

5. New generation mobile devices and applications

5.1 Towards convergence with hybrid PDAs

5.1.1 Multiple-purpose devices

Pagers, laptops, WAP phones, and handhelds are still selling alongside the new Microsoft smart phones, suggesting that consumers prefer to use multiple-purpose devices. At the same time, new hybrids like the Handspring Treo are appearing which support the convergence argument.

The new hybrids support instant messaging, wireless email and entertainment. Some have bar-code reading functionality.

Device operating systems include PalmOS, Pocket PC; Symbian. Pocket PC is suited to serious enterprise applications, whereas the strengths of PalmOS, despite its acquisition of ThinAirApps, lie chiefly with Personal Information Manager (PIM), corporate email and low data entry enterprise applications.

5.1.2 Internet access

PDAs can use the caching mechanism supplied with mobile browsers like *Microsoft's Pocket Internet Explorer*, *EudoraWeb* or *Link's Palmscape*, enabling users to bookmark and download favourite pages and browse them offline, and cache a history of visited sites.

The new Sony CLIE PEG-N760C is an example of PDAs that can get access to Internet using the synchronisation link with a PC, via for example, the free software provided by AvantGo. CLIE PEG-N760C combines distinctive design with a more powerful processor, a larger, high-resolution screen and in-built wireless features.

Web-based service for remote file access

My Docs Online, Inc., specialising in remote file access and wireless messaging solutions, offers a Web-based service for storing, accessing and delivering files on the Internet with 'anywhere, anytime, any device' file access. The service enhances the messaging capabilities of wireless devices, including Palms, Pocket PCs, RIM BlackBerry, Web-enabled phones, and Motorola 2-way pagers equipped with Motorola's vClient. The products are available through mydocsonline.com [25] or through partnerships with AvantGo, Bell Mobility, Nextel, OmniSky and Palm.net. [26]

5.1.3 Categories of hybrids

MobileInfo [27] categorises hybrid devices as follows:

- Voice Heavy, Data Light (e.g. smart phones with some PDA functionality)

- Voice Light, Data Heavy (e.g. PDAs such as Handspring with phone module, or BlackBerry)
- Voice Light, Entertainment Light
- Wireless-enabled PDAs (Pocket PC devices with enterprise data applications)
- Application-specific.

5.1.4 Example hybrids

These include: BlackBerry, Handpring, Pogo, Thera and XDA:

BlackBerry: voice capability and 'always on'.

BlackBerry(TM) is developed and produced by Research In Motion Limited (RIM). Marketed as: '*a wireless email solution for mobile professionals*', Blackberry offers push technology and a fully integrated package including software, airtime and a choice of advanced wireless handhelds promising easy access to email 'wherever you go' via a full QWERTY keyboard and a 14-line display; a side-mounted thumbwheel scrolls through options / text. There is a calendar, task list, contacts book and memo pad and you can send and receive SMS messages to and from mobile phones. BlackBerry is now being introduced across Europe on GPRS networks.

Handspring

Sprint PCS: offers Handspring's Treo Communicator, a GSM phone, Palm OS® PDA capabilities, integrated thumb keyboard as well as wireless Internet browsing and 'always on' wireless email. The new wireless Treo 270 has a non-wireless companion - the Treo 90. ZDNet find that:

"both products have their appeal, but the less-sophisticated Treo 90 may actually turn out to be the more groundbreaking product."
z.net.com [28]

HP iPaq Pocket PC H3950:

The update to the successful iPaq line of Pocket Pcs, 3900-series models now include the new, transfective LCD, backlit for use indoors but also reflecting ambient light, making it viewable outdoors in sunlight. Screen has better contrast with brighter colours than those of previous iPaqs and Toshiba's XScale competitor, the Pocket PC e740 (see further below). LCD and *digitiser* (glass/plastic that you tap with the stylus) are closer together, making it easier to tap accurately on the screen. The Intel XScale processor, the PXA250, runs at 400MHz. The extra speed will eventually enable better multi-media applications and better data-security systems when these become available.

Nokia: 9290 Communicator PDA

Available in the United States initially, the 9290 is about half the size of the original and features a colour screen and more robust interface. ZDNet

gave the Nokia a favourable review; while suggesting trimming the device's dimensions and adding GPRS compatibility. ZDNet liked its robust features, built-in keyboard, and sharp screen, finding it one of the better phone/PDA hybrids and reasonably priced. [29]

O2:

XDA, similar to the Handspring, but with 32 Mgs of memory and based on the Pocket PC platform.

Pogo

Pogo is an innovative hybrid device marketed as:

“the first UK wireless device to deliver full mobile access to the World Wide Web without the need for 3G technology” znet.com [ibid]

Intended as an Internet and email tool for teenagers and those in their early 20s, *Pogo* has an ergonomic design which means it fits comfortably in the hand. The intuitive interface is stylus driven and uses funky looking fonts and graphics. *Pogo* combines unrestricted access to the Internet with e-mail, SMS, diary, networked address book and MP3 capabilities. The patented technology uses the existing GSM networks *‘to deliver today what 3G promises for the future’*, differing from other current mobile devices by *Pogo*'s own compression-based technology which:

“delivers wireless Internet browsing at an effective bandwidth of 56Kbps, compared to the 9.6kbps of the GSM networks, resulting in a swift and pleasant user experience.” znet.com [ibid]

The *Lightweight IP Technology* used by the *Pogo* only transmits the information needed at any one time, dramatically reducing the bandwidth needed. A vast amount of personal data can be stored online and collected on log-on using the device. Extras like ringtones and new contact details can be stored or entered on the Web and then synchronised with the *Pogo* on the next dial-up.

CLIE PEG-T665C

Sony improves on the PEG-T615C-with a faster processor and MP3 support to make quite an attractive Palm OS PDA.

Psion

The *Psion Series 5mx* is marketed as the out-of-the-box mobile computing solution for busy executives and professionals. High screen resolution allows you to view full-page width documents e-mails and Web pages without horizontal scrolling. Delivering impressive speed connectivity and functionality the *Psion Series 5mx* is one of the leaders in palm computing.

Thera

Verison and Sprint PCS are selling *Thera* (Greek word meaning 'opening' or 'gateway'). A Pocket PC with phone capabilities, *Thera* will let users access their email accounts, send emails with graphics, browse the Internet and play games.

Pocket PC e740

Cheaper than HP iPaq Pocket PC H3950, Toshiba's Pocket PC e740 has two expansion card slots and built-in Wi-Fi connectivity.

5.2 New generation phones

5.2.1 Compact phones, smart phones, GPRS phones with multimedia facilities

Here are just some of the latest examples:

Alcatel One Touch 511

Weighing 75g, the compact phone is just 9.7 cm tall with excellent call quality via an internal speaker with enough volume so you can hold it away from your ear. A 96x65-pixel display handles WAP sites easily via the OpenWave browser. It only displays 4 lines of text at a time, albeit in large, easy to read typeface. More processing power would make it easier to use the phonebook for example.

Cingular Wireless: Sendo Z100

A multimedia smartphone running on Windows CE, phone integrates with Microsoft Outlook and Internet Explorer. The *Sendo lets* users send and receive e-mail, surf the Web , and access corporate databases, synchronising with desktop PCs. You can also stream video and listen to MP3 tunes on the Windows Media Player.

Kyocera Wireless – 4 new phones:

Designer of the first Palm-powered smart phone, Kyocera releases 4 new wireless phones in the US:

- 2325 and 2345 are metallic world phones with blue backlit screens. They have GPS, SMS, five games, predictive text entry and voice-activated memo and dialing, as well as a calculator, address book, alarm clock and stopwatch. Both are compatible with the Verison and Sprint 3G networks and can download ring tones.
- 5135, Kyocera's first clamshell-style phone, is tiny, stylish and weighs 3.1 ounces.
- 1135, compatible with both 3G networks, is compatible with only the voice capabilities of a 3G network, not data applications. Phone has SMS, selection of 25 ring tones, a calculator, address book, alarm clock and stopwatch.

LG InfoComm – 4 new phones

LG InfoComm (parent company Korean mobile phone manufacturer LG Electronics) tests the U.S. 3G market with new cell phones compatible with both *Sprint* and *Verison* networks, for example:

- *VX4100*, a world phone with a liquid colour display, BREW software and GPS.
- *LX5350*, with full-colour screen and GPS chip, it supports Java applications, instant messaging and streaming multimedia.

Motorola:

- *Accompli 008*, designed primarily for business travellers and expensive, phone nevertheless has youth market potential. *Accompli* is a tri-band cell phone for world-wide use. Use the built-in modem with your PC via either the IR interface or the cable supplied for synchronisation - GPRS starts up automatically with both. Phone has a colour display and a tiny *QWERTY* keyboard. Functionality is designed for one-handed operation: *Accompli* supports two-way paging, e-mail attachments, SMS and faxes - and has its own calendar, address book and note pad, task list and an alarm feature. An 'ink pad' enables you to draw small images, and there's a voice-memo recording function, a world clock, a currency converter, a calculator and even a blackjack game.
- *Accompli 009*: Similar to the 008, the 009 version offers 256-colour 120x320 TFT screen w/backlight, voice, data, Internet (albeit with a text-only WAP browser). Instead of a plastic stylus, there is a full alphanumeric keyboard and a user-configurable AutoType dictionary of abbreviations. The 009 supports multiple network and email profiles, with minimal effort to switch. The composer benefits from AutoText (predictive text input). There are 7 games (e.g. puzzles and playing cards), making good use of the *Accompli*'s colour and sound capabilities. Other features: SMS, GSM 800/1800/1900 + GPRS support, 9Mb memory, battery life: 5 hours talktime, 150 hours standby, headset and speakerphone supplied, PC sync cable, Java-compatible Wisdom OS. Dimensions: 97x71.5x 27.1mm, weight: 167g. The device takes nearly 30 seconds to power-up and engage the network – too long for comfort.
- *V60*'s anodised aluminium body gives it a sporty feel, albeit making is slightly heavier than many mobiles. It offers both GPRS compatibility and tri-band technology; twin-screen (like the Samsung SGH-A300) shows who's calling before you flip open the second screen - only 3 lines of text at a time, including the menu bar. Good call quality with few drop-outs. Standby quoted at 130 hours and talktime at 200 minutes. Fair-sized keypad.
- *V66*- GPRS-enabled, Tri-band (900/1800/1900 MHz), WAP 1.1 microbrowser, battery life: just 3 hours talk, 120 hours standby,

voice dialling, iTap predictive text input, dimensions: 84x44x20mm, weight: 79g. A good-looking, compact phone, the V66 has a small screen that only delivers 3 lines of text. 2 soft keys are mounted just beneath the LCD. Call quality is aided by its aerial. However there is a useful date book and set alarms to remind you of important appointments. You can change the LCD backlight from green to orange or red, and there is a Blackjack game. The V66 has no IR port, but does come with USB data cable. Motorola's TrueSync software lets you download contacts from the phone into Microsoft Outlook and vice-versa.

- A820 goes on sale in Europe and Asia later this year. Geared towards fashion but compatible with 3G networks, A820 contains a video camera, Bluetooth chip and the ability to send and receive multimedia messages. It also features downloadable ring tones, games and *Multi-call*, enabling users to make a phone call while using another application.

Nokia:

- 7210 is a high-end phone. Alongside a high-resolution colour display it features stereo FM radio, multimedia messaging and Java downloading capability. A so-called *world phone*, it can be used anywhere.
- 9210i resembles a mini-computer and has a full-colour screen. Users can send/receive email, Word and Excel documents plus PowerPoint presentations. Phone can view both HTML and WML sites. It also has Flash Player and can stream video.
- 8310 is small, and light but nevertheless has GPRS support, making it very fast. The 84 x 48-pixel LCD manages up to five lines of text. There is integrated FM radio and 4 games, including Snake, and 35 fixed and 5 variable ringtones for storing downloaded tones or the jingles created using the composer.

Panasonic:

GD88 is Panasonic's new GPRS phone; it has a colour screen, and comes with multimedia capabilities as well as a built-in camera.

Trium:

The Trium Eclipse is a GPRS phone which stands out from the competition with a 256-colour screen, capable of displaying up to nine lines of text, not including the menu bars at the top and bottom of the screen. A side-mounted jog-dial makes navigating through WAP menus easy. Organiser facilitators include a diary, calculator, currency converter, world clock, and voice memo facility. An infrared (IR) port makes it easy for the Eclipse to collaborate with an IR-equipped laptop to keep the businessman in touch whilst on the move. The colour screen also supports a variety of screensaver options and games: 2 games are

supplied, both in full colour. 30 ringtones benefit from the Trium's polyphonic ringer. The one drawback is the size needed to take this technology; even so it's a lot smaller and more stylish than Trium's 7110.

Samsung:

Samsung's sleek, fold-up cell phones include:

- *N400* with full-colour WAP display and supporting Verison's 3G wireless network will from summer support Sprint's 3G. Phone contains a GPS chip so that emergency services can pinpoint user location.
- *R225M* has blue backlit screen and features melodic ring tones, AOL instant messaging, calendar and phone book.

Sharp:

- *Z-800* will be sold by *Verison*: another world phone, it features colour liquid display screen. Instead of Java, it runs Qualcomm's *Binary Runtime Environment for Wireless* software: users can download games, news, email programs and financial applications.
- *Zaurus SL-A300* is a Linux and Java-equipped handheld computer with full colour screen and a full keyboard. There is also a screen-shot function so that users can transfer data from their computer monitors. Launched in Japan in July 2002.

Siemens:

- *SL45* - an MP3 player and WAP phone rolled into one, the SL45 is also a superb business handset with gaming facilities.
- *S45* comes with masculine styling and *Siemens'* now familiar user-interface: a four-way rocker switch, and two programmable soft-keys to navigate through the menu system. Unlike the SL45, this phone has no MP3 player (although there is a melody composer) and while the menu system looks the same, there is no memory card (the *SL45* came with a 32Mb SmartMedia card was supplied) and *S45* has fewer customisation options A big advantage: the *S45* has GPRS capability, making it very quick; browser is OpenWave. The LCD will cope with up to five lines of text at a time (not including the menu bar) and the font is a decent size.
- *S46*, for business users, supports all networks from AT&T Wireless and Cingular Wireless and will work on both old and new networks. Phone has monochrome screen and supports Microsoft Outlook and Lotus Notes.
- *M46* is geared to a younger audience; phone has Java software, a messaging tool and the ability to download melodic ring tones and screen savers.
- *C55*: weighing 80g, the phone can play and download polyphonic ringtones and can also record sounds. The polyphonic feature allows ringtones to be heard in up to 16 chords, making them

sound deeper and richer. Wireless Java gives the C55 advanced messaging and access to various entertainment applications. Also of interest to a youth market is the range of CLIP it covers and the ability to add pictures to address book entries.

Sony Ericsson:

- Sony *CLIE PEG-N760C* combines distinctive design with a more powerful processor, a larger, high-resolution screen and in-built wireless features.
- *Ericsson T68*: specifically targeting the youth market, this is a sleek GSM phone with colour display and General Packet Radio (GPRS) Services connectivity, enabling 'always-on' Net connection and live video streams. You can send messages via MMS, while in-built Bluetooth capability lets you wirelessly connect with other nearby Bluetooth devices, such as digital cameras or computers.
- *P800*: Sony Ericsson's most sophisticated phone. It has an integrated camera, full-colour screen and the ability to send and receive multimedia messages. Users can store photographs of the contacts in their address books. Phone has some PDA functions, such as a calendar and note-taking facility. It supports 3G networks and can view Word documents, PowerPoint presentations and Acrobat documents.

Toshiba:

Company has released *J-T51* to be sold by J-Phone in Japan and an i-Mode mobile Internet phone for Europeans:

- *J-T51* is a flip-up phone with full-colour screen that supports 10 lines of text. The phone also contains a digital camera.
- *TS21i* is a compact phone sold by KPN Mobile; it has large colour screen for i-mode mobile Internet content: games, news, directions and email.

5.2.2 Camera and video phones

CMOS versus CCD

Camera phones using CMOS chips are low power devices suitable for mobile phone usage. Hitherto definition was just 352 x 288 pixels - Sharp's *J-SH51* to *J-Phone* now provides 640 x 480 pixels (VGA).

CCD (Charged Couple Device) is the alternative to using CMOS technology. *Sanyo's* new CCD offers low power consumption via a frame-transmission (FT) system for digital cameras as opposed to the usual Interline Transmission (IT).

'Pulls' for camera phones

In Japan, these include picture email such as *J-Phone's Sha-mail* which moved 3.5 million units in three months. CCD manufacturers *Matsushita*, *Sharp* and *Sony* are poised to supply handset manufacturers when demand picks up.

Example videophones

Japan's *DoCoMo* is selling a videophone, compatible with its 3G networks.

5.2.3 Disposable phones

znet.com has information on disposables [30]:

PS Call Me is the postable phone designed by Stephen Forshaw which won a recent Sony-sponsored competition. Capable of making one call only, the device fits all the electronics into a tiny computer chip and is so small that it can be stuck on to paper and posted in the mail. A cardboard version has already been designed by an American inventor.

Hop-On's disposable phones are recyclable, and carry 60 pre-paid calling minutes in the U.S. They use 2G chipsets from Intel. Distribution is via retail chains.

Uses

Disposable cell phones could become more widespread, replacing cellular cards.

The disposables would be useful in emergency situations. They could also be used instead of traditional greetings cards for special occasions: the sender programmes the phone with the right number for the recipient to call to get their greeting. A recorded message could also be left to ensure the call wasn't wasted. Greetings-phones could sell for under £10.

5.2.4 Phone accessories

The existence of a wide range of accessories, which include 'gimmicky' products aimed at the youth market, can be seen as a strong indicator of a mobile youth culture:

Interchangeable covers

As well as downloading fun software such as screensavers and ringtones, users can 'personalise' their mobile phones with interchangeable covers. In Japan, young people even dress up their phones to look like dolls.

Storing your phone

Where do you keep your phone when not in use? Some of the imaginative solutions:

- Cyberpocket is a belt clip that extends outwardly, holding the organiser horizontally to enable one-handed use.

- Palm and Japan's Sanyo Fashion House offer a line of unisex raincoats with special inside pocket for Palm Pilot or PocketPC. Waterproof and lined with anti-static material, pocket is secured with a button emblazoned with the Palm logo. There are other special pockets for gloves, money, passport, sunglasses and cell phone.
- Levi's new Dockers Mobile Pants have no less than seven special deep, wide and mesh-lined pockets for electronic devices, including two 'hidden' thigh pockets.
- SeV: the Scott-E-Vest, invented by Chicago corporate lawyer Scott E. Jordan, features not only an array of large pockets but also has Velcro 'conduits' for running wires from gadget to gadget, or through the collar to a headset or earpiece. Jacket is water-repellent and available in black or khaki; future versions will have wide choice of colours and fabrics plus the option of removable sleeves.

5.2.5 Safeguarding your phone

Kobra is an invention by *Allied Commercial Developments* to safeguard mobile phones; the device will emit a 120-140 decibel noise if a handset is torn away from a user's hand; this works via a pin being pulled away from a strap, which can be attached to a wrist, belt or bag.

5.2.5 Market trends

Sales of 2.5G and 3G handsets were hit last year as consumers awaited the new generation, including colour-screen phones. Operators stopped subsidies as Europe reached saturation point for high-value users, and there has been a thriving market for second-hand phones.

The business is highly competitive with decreasing margins. Manufacturing is beginning to move to Asia. Mergers and collaborations are another result, for example Ericsson joined up with Sony and Motorola to license designs to other manufacturers, thereby protecting their IP and realising some profit. Despite the market down-turn, competition has led to a bullish response from vendors competing for a share of the cell-phone market with proliferation of new phones; as has been seen in 4.3 above, these include camera phones, disposable phones and new cell phones with Openwave browser which let you download ringtones, wallpapers, screensavers and music.

2.5G GPRS and 3G handsets are still in short supply, but this problem may be resolved during the second half of 2002. For example, Motorola is releasing 3G wireless phones, as is *Nokia*, claiming a 5% increase in sales last year and a 35% market share. *Microsoft* optimistically sets its sights on 25% of the market by next year, with smart phones with wireless data capabilities and slightly bigger and higher resolution screens.

Verison Wireless, Sprint PCS and VoiceStream Wireless are selling Windows CE products to their customers – at the same time all three also sell products with competing platforms such as Java and Qualcomm's BREW technology, the Palm operating system and Symbian EPOC.

Dual-mode handsets - bridging the 2G-3G gap

Competition has led to further significant developments in respect of connectivity as GPRS devices bridge the gap between conventional mobile phones and 3G technology. These 'dual-mode' handsets may lack the speed of 3G but do have a continuous Internet connection and are a vital first step in the introduction of the new service. However in the UK a lack of dual-mode handsets means that UMTS will be limited to a smallscale service in some of the UK's major cities and may not be widely available until the first half of 2003. You may still need your 2G phone outside these areas.

Call for more coordination between handset makers and network operators

The handset is the main interface with the consumer but is not optimised for the network operator. The situation is complicated by the multiplicity of networks across Europe, which means services must be able to roam from one network to another. Moreover dropping handset subsidies makes it difficult to sell high-end, feature-rich handsets. Vodafone wants more coordination between handset makers and network operators to lessen customer confusion and to make it easier to implement 3G wireless services.

Need for handsets with greater capacity

3G networks require handsets with more capacity:

- bigger screens, especially for video clips;
- better solutions for data input and output;
- bigger memories, e.g. for storing MP3 files.

Handsets themselves need to be bigger, to accommodate batteries to support the range of uses and chipsets for both existing and new mobile networks.

Vodafone proposes a customised menu on each phone, with one-button access to the network operator's value-added services, and with the facility for them to brand the handset hardware, and to program the phone with branding messages.

5.3 Interim summary and conclusions for m-learning

New generation phones and hybrid PDA's are emerging, with more bandwidth and speed to transfer data. Increasingly, handsets are turning into 'world phones or 'microbrowsers', capable of dealing with the Web, receiving and sending e-mail, as well as storing MP3 files and other data. High screen resolution allowing you to view full-page width documents e-mails and Web pages without horizontal scrolling, together with significantly more processing power, afford more options to m-learning developers.

Data entry continues to pose problems; interesting solutions are integrated keyboards such as those offered by Handspring and Blackberry, but people may not want these cut-down PCs. Short-range radio technologies like Bluetooth make it easier to exchange information between devices, but en route you are unlikely to have more than one device with you.

Camera based phones can contribute to authentic learning, by offering an environment supporting media redundancy and by providing a non notational solution to mapping individuals milestones and progress. Their significance should not be underestimated.

6 Smart Web applications

6.1 Interactive intelligent programs

Smart Web applications are interactive intelligent programs, bringing us personalised information and the Semantic Web, i.e. the Web as a learning network connected by Web Artificial Intelligence (AI) Service Portals and utilising components of AI agents.

Successful smart applications will be:

- time dependent - with rapidly changing information that is always up to the minute;
- location dependent - with services that know where each user is and respond accordingly;
- critical - containing 'must have' information that is vital to each user;
- reliable - so that users can rely on information when there is no chance to check;
- personalised - highly targeted at a particular individual or affinity group.

6.2 Smart portals

6.2.1 Personalised Information Portals (PIPs)

PIPs are personalised points of entry and include: MyYahoo, Netcenter (Netscape), MSN (Microsoft) and AOL.

6.2.2 Enterprise Information Portals (EIP's)

EIPs use XML to integrate previously separate legacy systems, affording a single point of entry to these. EIPs link mission-critical applications such as email, groupware, workflow, collaboration and Web Services.

6.3 Synchronisation technologies

6.3.1 Effects of competition

The development of *i-Mode* means that established media companies such as Pearson, Reuters, Bertelsmann, Dow Jones and News Corporation, who were already competing for market share of the Internet against providers offering made-for-medium content and aggregation services, now increasingly face competition from new types of players, including digital content and e-commerce providers. These companies are creating solutions specifically for Mobile Internet, incorporating wireless e-mail and groupware which utilise synchronisation technologies.

6.3.2 Enabling standards

nwfusion [31] has information on Enum and Session Initiation Protocol (SIP); these are standards which enable telephone calls over the Internet:

- Enum promises a single point of contact for multiple communications devices, from phones to PCs to fax machines.
- SIP is a signaling protocol used to establish Internet telephone calls, multimedia conferences, chat sessions and interactive communications.

6.3.3 Example implementations

These include:

IBM's Web Sphere Everyplace Access (WEA)

WEA uses synchronisation technologies to afford remote access to e-business applications via virtually any device on any network, from CDMA-based digital cellular networks to 802.11-based wireless LANs. From a single platform, WEA's core services build, deploy, manage and extend existing e-business applications to multiple wireless devices, e.g. PDAs and mobile phones.

WEA leverages the rest of IBM's Web Sphere suite, including Web Sphere Application Server, Web Sphere Portal, DB2, Lotus and Tivoli, and is compatible with key industry standards, including SynchML, WAP and LDAP. For more information: <http://www-3.ibm.com/pvc/index.shtml>

iMobile Suite:

Client and Server modules allow development of applications requiring DBMS synchronisation on handheld devices.

Extended Systems' XTNDConnect Server

The server allows mobiles to synchronise directly to server applications, enabling deployment of mobile applications and access to information via wired or wireless connection.

Palm HotSync® Server

A platform for seamless wireline and wireless access methods for synchronising handheld data with corporate databases and mission-critical applications such as Microsoft Exchange and Lotus Notes groupware solutions.

Xcellenet Afaria:

Manages laptops, PDAs, smart phones, RIM pagers, WinCE devices etc. from a central location. It keeps devices running, deploys applications, checks inventory and provides automatic updates.

Open source technology: JXTA

JXTA is Sun's new 'core architecture' and is written in cross-platform Java. This open-source technology makes it easy for developers to build distributed applications; these rely on P2P (peer to peer): a model where connected computers communicate directly with each other instead of via a central server. While other P2P music-trading applications such as *Napster* and *Gnutella* are also interesting, *JXTA* technology offers much more potential. For example, *PeerSwitch*, from a start-up called eMikolo 'turns clients into routers', reducing bottlenecks on the Internet. Wireless devices which run Java can talk to each other directly.

6.4 Wireless email and groupware

6.4.1 Web conferencing

Raindance Web conferencing

Raindance combines phone and computer to provide simple, powerful tools for:

"everything from reservationless phone conferencing to fully interactive Web conferencing with application sharing, white boarding, polling, chat and more."

Centrinity FirstClass

With a layered approach, the FirstClass® core architecture is accessible from multiple devices and designed to support emerging communication technologies. It claims to offer scalable software solutions which enable teams of individuals to work efficiently and cost-effectively online through self-service electronic communication:

"Accessible through one graphical user interface and independent of network connection path or device, the Unified Messaging (UM) module of FirstClass is the first of its kind to consolidate email, voice mail and fax in a single inbox through a collaborative digital data store. Unlike other integrated collaborative environment (ICE) and UM products, applications based on Centrinity's FirstClass architecture leverage one collaborative digital data store to facilitate knowledge management through communication and collaboration ... users switch seamlessly between messaging, collaboration and calendaring ... each of the layers may be extended without disturbing the others."

Linktivity:

Advertises Web Demo [32], a Web -based, conferencing and collaboration software tool, allowing you to conduct meetings in real-time.

6.4.2 Instant Messaging (IM)

IM is a vital part of Internet Conferencing software, allowing two people to communicate in 'real time' over the Internet - much faster than email, and you can track when another person logs on and logs off the Internet by entering a screen name or email address. Some versions also give you the option of exchanging files with one another. IM is not a new concept; Bulletin Board Systems allowed real time conversations with the system's operator, while Unix talk programs and Internal Relay Chat programs have been around for a while.

IM primarily works like a client/server model. When the client connects to a central server, this verifies your identity and registers you as being online; by this means when users register and connect, they know who else is online. Unfortunately IM programs (such as AOL Instant Messenger or Infoseek's Instant Messaging) use incompatible protocols. This means persons needing IM contact with each other must have identical software.

Privacy option: if you are busy and don't want others to know you are online, you can opt to hide the fact that you are online.

Hubz – an example implementation:

Hubz instant messaging technology turns Web pages into a Web-based "walkie-talkie", allowing real-time, two-way communication between Web surfers without special plug-ins or client-side software, thereby acting as a powerful community-building tool:

"With Hubz, every Web page is now a destination; dynamic, alive and filled with other people with similar interests." Hubz.com [33]

6.4.3 Groupware servers

A groupware server should support leading backend messaging platforms such as MS Exchange and IBM's Lotus Notes. However the interests of equity investors may affect support given to networks and consumers need to be wary of this.

For example Microsoft's Mobile Information Server promises superior technical and functional integration with MS Exchange, however Microsoft has passed its equity investment in Wireless Knowledge (which was on the same track) to Qualcomm, which could be bad news for consumers, as Wireless Knowledge will be under pressure to support Qualcomm's CDMA network first.

6.5 m-commerce enabling technologies

6.5.1 Web Services

Web Services, i.e. the middleware that enables and simplifies Web application-to-application connectivity, differ from other forms of middleware in that they are based on XML standards. In theory, these standards will create hub-and-spoke configurations, rather than the so-called spaghetti code that results from point-to-point connectivity. [34]

Interconnected IP-based LANs and WANs which enable cost-effective Web -based applications using voice, data, and video are becoming more established via the .Net or Java platforms and are utilised by the other m-commerce technologies below.

6.5.2 Using your phone as a credit card

It is already possible to use a mobile phone as a credit card, for example to buy goods over the Internet. Enabling technologies include:

Micropayments effected via cellular billing systems:

Using a mobile phone to pay for goods and services is possible in parts of Europe but initially British mobile phone users were restricted to using their phone number to buy ringtones or goods over the internet; then a deal with *Paybox*, a German payments company backed by Deutsche Bank, allowed so called m-commerce in the UK too. *Paybox* takes cash

directly from a caller's bank account, whereas other competing payment systems need the caller to set up a separate debit account, or to pay via a monthly contract.

Payment cards:

Cards slot into handsets to enable payments to be made via the handset independently from the cellular billing system.

Multislot handsets:

Different payment/credit cards can be placed in the handset catering for different user needs.

6.5.3 Internet banking

The UK's Nationwide Building Society is an example of how banks can now enhance their main Internet site with a WAP site, thereby affording users true remote access from which they can manage up to 10 accounts. Using the Nationwide service you download settings to one of several specified Nokia mobile phone types and access your accounts after a full banking registration. A customer ID facility lets you use someone else's phone for access.

Security issues

m-Commerce is still in its infancy, and despite some assurances to the contrary, security scares at some leading UK online banks earlier this year mean it could yet pose even greater risks than the fixed-line internet.

The 'WAP gap'

The so-called 'WAP gap' allows hackers to access data: a message sent from a WAP handset to an online bank server goes through *three* stages: crossing the GSM telephone network to a WAP gateway, it is there decrypted and then re-encrypted to make it readable by the bank's computer, before being transmitted from the WAP gateway via either the public Internet or a private network to finally reach the bank.

Risks with 3G phones

The use by 3G mobile phones of open protocol instead of WAP standard will still pose risks, albeit different ones: as device capability and data sharing increase, this may increase security concerns, and concerns about the potential of malicious virus activity, such as viruses.

6.5.4 Location-based m-commerce

Mobileinfo.com has information [35] on Location Based (or Location-Specific) Services (LBS) for Web-enabled phones, which deploy information about the current location of the device user. Ideally the information is both location-specific and personalised:

End User:

Applications providing information on traffic, weather, driving directions, entertainment options, wireless advertising, store location, etc.

Developer & vendor:

Mapping, routing, real-time GPS navigation, proximity searches, destination guides, tracking (E-911, vehicles, assets, friend or buddy finders), telematics, location-based billing, advertising, etc.

E-911 standard

Public safety concerns in the US have contributed to the mandating of E-911 standard, affording more precise location based applications. Early uptake will be aimed at the younger age group, but is expected to be slow.

6.5.5 Authentication

Authentication is another major concern. Implementation of Virtual Personal Network (VPN) security in mobile devices will help. Baltimore Technology has agreed to let Motorola to use its digital certificates for identity checks. Vodafone maintains that m-commerce could soon overtake fixed line Internet banking via strong client authentication enabled by user's private keys in association with the SIM card contained within the handset.

However especially with E-911 implementation you forfeit some of your privacy because network providers know who you are, and your location. <http://www.mobileinfo.com/LocationBasedServices/index.htm>

Avoiding scams

Mobile phone users can be conned into paying for unsolicited premium-rate text messages that promise cash prizes or invitations to join adult chatlines. A method known as 'reverse SMS' means that users responding to the offers trigger more text messages which cost up to £1.50 to receive (messages usually cost about 12p).

Scams make use of powerful computers to randomly generate mobile phone numbers, which are then indiscriminately sent text messages. Mobile phone networks can block them but often users are unaware they are paying for the messages until it's too late. Orange is working on developing technology that will automatically filter out such messages.

A solution for mobile phone users is to register their phone number with the Oftel-run Telephone Preference Service, which automatically blocks unsolicited bulk messages 28 days after registration. However it also blocks access to services such as sports scores or news updates.

6.5.6 Security solutions for handsets

Encryption

Applian PocketLock lets you encrypt the data on your Pocket PC and protect it with a password. You can select individual files or entire folders for encryption.

PKI and SIM toolkit

Public Key Infrastructure (PKI) is a system designed to inhibit fraud. The SIM toolkit is another preventative measure, enabling content or service providers to change handset features by reprogramming the SIM card.

Emerging solution

Teleporting is an emerging solution: Australian scientists have been experimenting with quantum entanglement, reportedly managing to adopt a similar method to that used by *Star Trek's* fictional teleporter. Using quantum entanglement, an encrypted laser beam message is sent, then deconstructed and simultaneously replicated a small distance away. This means that intercepted messages would be indecipherable and could prove vital for banks and organisations needing to ensure that sensitive data remains completely secure.

6.6 Interim summary and conclusions for m-learning

6.6.1 The Semantic Web

The Web is set to become a Learning Network through smart Web applications, built with adaptive software languages and connected by Web Artificial Intelligence (AI) Service Portals, and using components of AI agents.

6.6.2 New email and groupware solutions

Potential for m-learning

Wireless email and groupware for business professionals have obvious potential for m-learning implementations. Email engines cater for popular platforms such as BlackBerry, PalmOS, smartphones and Pocket PC. Currently however cost considerations may inhibit use.

Choice of access environments

Real-time access environments allow users continuous connection to the server: data is viewed as it is entered with no local storing of data or applications. In asynchronous environments, data and applications are downloaded from the server and can be stored on the devices. Users are freed from the vagaries of network status or available bandwidth: data is updated locally and at server via synchronisation sessions. These technical benefits, plus reduced queries and 'user idle time' and controlled

communication costs, make them a good choice for m-learning applications.

Choice of groupware server

A groupware server should support leading backend messaging platforms such as Lotus Notes and FirstClass. However the interests of equity investors may affect the levels of support given to networks: consumers need to be wary of this.

Market trends

Consumer email and consumer m-commerce have still not really taken off in Europe. Until the security issues of end-to-end encryption and authentication are seen to be resolved, m-commerce services may not attract enough users to make them profitable. Negligible revenue for most carriers is expected shorter term and *e-learning* companies may find that it is more difficult to make money selling products and services via mobile phones than it is via the fixed-line internet.

Potential growth areas include location-based m-commerce and wireless advertising, although TA users may not want random advertisements popping up on their mobile phone. Wireless email and groupware will be more important for *m-learning* in the foreseeable future; so too will messaging, mobile games and music, as will be seen below.

7. Text messaging, multimedia messaging and mobile games

7.1 Short Message Service (SMS)

7.1.1 A 'killer application'

Although services such as email will be important in the longer term, the 'killer application' of the GSM industry to date has been the SMS, also known as Txting, Texting, Text Messaging, Text Messages, Mobile Text Messages, and g-mail.

SMS is a feature available in most modern digital phones, that lets users receive and send short text messages (from 150 to 160 characters) to other cell phones, usually limited to phones activated on the same network. Free Web services appeared to support the phenomenon, then slowly disappeared or began to charge for Web to SMS services; phone users usually have to pay a monthly fee to their service provider or up to 12p for each text message.

7.1.2 General usage

In late 1999 SMS took off in the UK as a popular form of discreet and low-cost communication. Silent, secret and cheap, SMS combines ease of use with convenience and efficiency, thereby making up for a lack of multimedia capability. Without having to talk on the phone, you can keep costs down and get your message over at a time and place convenient to you.

There's also the attraction of undercover glamour in sending messages in code - the 'shorthand' language stems from the unwieldy way you have to input, e.g. Press key 2 once for A, twice for B, three times for C, etc. WapOnline's research indicates that three-quarters of respondents use SMS to avoid tricky conversations. The research also reveals that an impressive 72% said they'd prefer to lose their wallet than their mobile phone – perhaps because 86% said they felt anxious without their phone. 23% trade their ring tones in for new ones every week.

Gossip on mobile phones has become "*the equivalent of social grooming among primates*", according to a survey by Oxford-based Social Issues Research Centre for BT Cellnet. Of a sample of 1,000 adults, a third kept their mobiles for emergency calls only and 17% people said they used them mainly for work. However most used them mainly for keeping in touch - three quarters chatted on them at least once a week and a third gossiped every day. Most chats lasted only five minutes. The survey found that text messaging had become "*the 21st century equivalent of saying hello over the garden fence*" - a modern antidote to the pressures and alienation of modern life. Men gossiped most: 27% as opposed to 21 % of women, but 26% of men referred to this as 'keeping in touch'. The report highlighted the importance women attached to detail and feedback in gossip.

Among latest developments: Paul Darby applies the principles of Feng Shui to mobile phones, reportedly adapting the 6,000 year-old Chinese discipline for phones and offering the results online.[36]

7.1.3 Mobile youth culture

In June 2002, a young researcher at the Ultralab sent over 950 text messages (!) Recent research suggests his case is not unusual: according to the Mobile Youth Report, January 2002 [37], UK teenagers sent a staggering 500 million text messages during 2001 while German youth sent 900 million. In some markets almost 90% of young adults and older teens own mobile phones, and that increasingly young adults are becoming:

"more cynical towards traditional forms of marketing ... more focused on self-defining their own culture."

Mobile Youth identifies:

"the strong existence of a "mobile culture" unlike any seen with other technologies. The mobile is an icon of the youth generation and the culture that determines its usage patterns has, in the most part, been internally defined by youth themselves. This culture is complex and not easy to decode at first glance. It changes radically between the genders and the different age strata within our focus demographic. The cultural norms determine the acceptance of new services, their associated levels of "cool", how the phone is used, why it is used and, importantly, what meaning the device has in the future."

It remains to be seen what differences the *m-learning* project will encounter between UK and Italian cultures. However usage may prove to be very similar. Mobile Youth, whose focus was the 5-24 year old demographic in the USA, Canada, U.K., Australia, Germany, Italy, Japan, China, Ireland, France and Spain, finds that:

"although each market has particular characteristics, patterns of mobile phone ownership, adoption and its associated culture are similar across many of these countries."

Interestingly, the report attributes a lack of marketing to youth's adoption of SMS and calls for research into marketing strategies.

7.1.4 Some example SMS services

Free service

ICQ (www.icq.com) is one of the few free SMS services which remains; ICQ users are able to send txt messages to international mobile phones. Mobile phone users are then able to txt back to the ICQ user. It costs to txt back, ICQ get a cut of the fee for the response traffic which they generate and this assists ICQ to keep the service free.

Email alert

Talk21 (www.talk21.com), which is owned by BT, used to offer a free email service supported by free txt messages sent to mobile phones; every time a new email was received by a talk21 user a txt message was sent to alert of the email. talk21 now only alerts for the first email of the day. Genie (www.genie.co.uk) still offer the every email alert service, but the service is very slow and can take 12 hours to alert.

Interactive experience

Lycos offers an interactive mobile experience, users are able to see when other Lycos users last logged on and how many txt messages each user has sent each day. Lycos limits the user to 10 txt messages to mobile phones and unlimited messaging to other Lycos users.

Ringtones, logos

On Nokia phones, users can receive new ringing tones or replacement background logos in an SMS text message after placing an order on a specialised Web site.

projectsms: a possible m-learning application

This organisation [38] offers services and applications which appear of interest to *m-learning*:

“a complete SMS project development and two-way communication service ... Imagine being able to communicate with your clients, youth groups, staff or other target users, wherever they are, at any time. SMS (Short Messaging Service) text messaging on mobile phones makes this possible and projectsms can provide you with the ideas, the content and the tools.”

The SMS project development and two-way communication service includes:

- Conceptualisation and design
- Creative writing and content creation
- Web-based Messaging Centre with comprehensive toolkit for two-way SMS communication
- Integration with online databases

Its applications include:

- Youth contact programmes (e.g. drug and alcohol advice)
- Educational projects
- Sports club
- Staff contact with job vacancy alerts

Halfbakery:

Interactive software: a chance to contribute endings to stories already begun.

7.1.5 Market trends

Phone manufacturers like SMS, as it's another reason for people to buy their products. Network operators like it, charging up to 12p per message.

Logica, the text messaging and IT services group carrying over half of the world's text messages, has however seen its profits and income so far this year fall below worst estimates. This turndown is caused by stagnating growth in its text messaging unit, in turn caused by a slowdown of its investment in next-generation mobile networks.

Japan's J-Phone, controlled by Vodafone and Logica's biggest customer, has slashed spending on messaging networks. Logica's core IT services, like those of rivals CMG and Xansa, have also been hit throughout Europe by the impact of the global slowdown.

A real benefit to the networks and manufacturers is that messaging has got people used to receiving data over their mobile phones. As will be seen below, Multimedia Messaging Services (MMS) is the latest development in the sector.

7.2 Multimedia Messaging Service (MMS)

7.2.1 The next 'killer application'?

Mobile messaging is evolving beyond SMS text with the introduction in 2002 of MMS, similar to SMS, but with graphics, audio and even video clips. Importantly for the operators, all of the content is provided by the customers.

The transition to MMS is seen to be as important for the mobile phone as the transition from DOS to Windows was for the PC.

The phenomenal success of SMS has led many in the industry to believe that it will be the next generation of messaging that will drive the take-up of GPRS and ultimately 3G. Not only is it faster than WAP, MMS should be easier for consumers to understand than WAP because it is based on their current behaviour, a view shared by the UMTS Forum, which predicts that 33m consumers and 13.7m business customers will be making use of MMS by 2005.

7.2.2 MMS Interoperability Group

Software houses CMG, Logica and Comverse have founded the MMS Interoperability Group under the auspices of 3GPP and WAP Forum, where Openwave is among the companies seeking to compete within the sector.

7.2.3 Emerging applications

Wireless postcards

Sprint PCS plans to give subscribers the capability to send and receive pictures with text messages on their cell phones by end 2002. *LightSurf* will power the service.

Mobile video-conferencing

NTT DoCoMo has just made it possible for four people to videoconference on their mobile phones simultaneously. Currently only available on two of their 3G phones, the service will enable meetings to be held between up to 4 people at one time, allowing callers to see each other while they talk

and switching to show each speaker as the meeting progresses. 35 Japanese firms are taking part in the trials, which run until September 2002.

7.3 Mobile games, entertainment

7.3.1 Commercial developments

European markets are about to become booming markets for mobile games, with mobile devices recognised as one of the most important platforms for game development. [8]

Sony Ericsson recently teamed up with two gaming companies to challenge *Nokia* in mobile entertainment. The new company collaborates with *iFone* and *Synergenix* to create games that users can download for free onto *Sony Ericsson* phones.

The new Mobile Games Interoperability Forum (*Ericsson, Motorola, Nokia* and *Siemens*) aims to provide a consistent environment for mobile gaming, using technologies such as *Java 2 Micro Edition (J2ME)* - a subset of the full Java platform designed specifically for embedded devices and already used in some phones - and *Macromedia Flash Player*.

While commercial developers have not yet made much of a mark on the PDA games market, freeware and open-source products include emulators for consoles such as the Nintendo Gameboy and ports of popular PC games such as *Doom* and *Quake*.

7.3.2 Role-play games (RPG) and multi-player interaction

Over the last two years WAP games have appeared which are akin to roleplaying adventures; but, limited by the medium, player interaction is very slow. Even so, opportunities for multi-player interaction afforded by in-built networking capability are surely where mobile gaming can make real advances over traditional platforms and where there is strong potential for developing m-learning applications.

Delivery via new PDAs with greater processing power

New PDAs offer greater processing power (currently up to about 200MHz), bigger screens and more RAM, and can run games which are graphically much richer and more complex. The multiplayer possibilities have not really been explored yet but this is changing as the line between PDAs and mobile phones become blurred.

Supporting multiple players: CybikoXtreme

Marketed as a toy for 'teens and tweens' the latest *CybikoXtreme* is an organiser-pager-games machine similar to a wireless Palm Pilot, with a processor fast enough to support real-time wireless gaming with multiple players. Leander Kahney of *wired.com* claims it has a cult following

among US high-schoolers, used to form local wireless micro-Web communities country-wide:

“With Cybikos, kids can wirelessly message each other, play networked games and share files. The device also includes an organiser, dictionary and scientific calculator. But best of all, there's no network or connection charges ... The Cybiko system is almost completely peer to peer. Cybikos have a range of 150 to 300 feet, depending on conditions. Users can connect with friends in the area and form "swarm" networks of up to 3,000. ..The system also allows users to island hop, potentially creating connections between people miles away — as long as there's enough Cybiko users between them.”

7.3.3 Music and creativity

MadPlayer is a hand-held digital music player/recorder that allows you to create, play with, change, listen to, and store music, even when you're on the move. Music created in this way is copyright free so it can be legally up-loaded, downloaded and shared electronically with the global music community without concern about copyright infringement.

With access to a soundbank of over 600 instruments and sounds, MadPlayer's proprietary software Generative Music Algorithms (GMA) will randomly create limitless music in 19 styles and genres and even has a karaoke machine, FM radio, and fully-functional MP3 player, enabling storage of pre-recorded music downloaded in all today's popular file formats - MP3, WMA, MIDI etc.

“Using a joystick, effects buttons and a simple graphic interface you can choose the music style you prefer, then change various aspects of the music (drums, lead, bass, riff, instruments, voice), add samples and effects to the music and save and share your songs on the fly, in real time.”[39]

7.4 Interim summary and conclusions for m-learning

Mobile games, SMS and MMS have obvious potential for *m-learning* implementations:

- WAP 2.0 push technology is attractive, with the potential for supporting interactive learning. Youth interest in games can be supported via WAP in-built networking capability and freeware/open-source products.
- SMS is more than just a passing fad, it is a communication medium integral to young people's lives, whereby cost remains an issue. The asynchronous nature of SMS is key to its phenomenal success.

- There is a very clear move towards MMS and other image and sound based messaging and interfaces.

Field research is needed to see how much the newer and more expensive Web-enabled phones, MMS and music technologies will appeal to TA users. 'Just a phone' - that can use SMS - may still prove to be what they want most. The problem is currently that image based services are perceived as a premium rate activity; those who may benefit most immediately from their adoption are likely to be excluded by pricing in the short term. If so, we must design applications with this in mind, while at the same time remaining ambitious and seeking to engage TA audiences via the new technologies – on past performance cost is likely to come down over time.

We should investigate how far voice navigation and unified messaging are likely to be important, as well as the ability to create learner profiles, for example so that tutors/mentors can use them to engage with learners on a personal level.

8 Towards a pedagogy for m-learning

8.1 Need for a shared pedagogy

8.1.1 Challenges for developers

As devices that were initially sold as expensive business solutions become more affordable, their development as learning tools becomes increasingly viable.

Our need for m-learning is to build learning resources that creatively exploit what makes mobile devices unique. Computers are powerful mind tools: increasing in complexity, but with an interface which presents an illusion of simplicity – at key stroke or mouse click, a train of operations is set in motion that is both invisible and unknown to the user. User-friendly interface is key, allowing us to interact with the computer - and to control it. Laurel [41] focuses on an essential issue in interface design: how can we make the interface more powerful and more empowering?

Further challenges faced by m-learning content developers include:

- How to develop m-learning content and services that can appeal to young adults and can promote autonomous learning and a learning culture?
- How to harness the new microportal technologies and use them effectively to communicate with target audiences to raise their awareness of learning needs and opportunities?

8.1.2 Move towards a more multidisciplinary approach

Design problems can range from the purely technical to the strongly political: such tensions, together with other tensions such as those between speed and intuitiveness, underline the need for a move towards a more multidisciplinary approach in the design process. Elizabeth Murphy cites Erickson:

"Psychologists, graphic designers, writers, industrial designers, and programmers all have essential contributions to make to the design of an interface" he argues. "Yet each discipline has its own priorities and perspectives, its own methods, its own criteria for success. Often these are in conflict with one another." [42]

There is an increasingly felt need for a shared pedagogy and this will be developed in Phase 2 of m-learning. The proposed approach below is informed by the research into usage undertaken by this report, and is intended as a starting point for the debate.

8.2 A social constructivist approach

Accommodating different learning paradigms

Both the project partners and TA users of m-learning products are likely to have strong preferences in respect of learning paradigm. A key challenge therefore lies in accommodating differing paradigms within any pedagogical framework for *m-learning*. An online community of practice can complement realworld debate on this issue.

Learning ecologies

Where online learning communities are linked to realworld learning events, they can be seen as learning ecologies. Ultralab's successful pioneering work with online communities of practice, creating such learning ecologies, is based on social-constructivist convictions.

Social constructivism

Social constructivism emphasises intrinsic learning through social interactions such as modeling or imitation. Supporters of this theory hold that where students are supported in becoming more autonomous learners (i.e. facilitated in considering their own learning goals, identifying learning needs and strategies in terms of these, exercising choice and liaising with others in putting together their own learning programme) this promotes both self esteem and intrinsic motivation, enhancing learning outcomes in the short term and promoting life-long learning and interdependence. [43]

Designing for communication and interaction

It is reasonable to suppose that the pedagogical value of successful m-learning applications will lie in the extent to which they are easy to use,

cost effective and absorbing, and, in combination with the other m-learning products, can foster autonomous learning and a learning culture among target audiences.

John Seely Brown points to the success of the Web:

"... where each of us is part consumer and part producer"

and where is perceived:

"... an interesting shift between using technology to support the individual to using technology to support relationships between individuals. ... With that shift, we will discover new tools and social protocols for helping us help each other, which is the very essence of social learning. It is also the essence of lifelong learning a form of learning that learning ecologies could dramatically facilitate. And developing learning ecologies in a region is a first, important step toward a more general culture of learning." [44]

Whatever the characteristics of the different m-learning tools therefore, a key feature of an overarching m-learning pedagogy must be to support virtual networked and collaborative learning.

With this in mind, m-learning developers should seek to design for interactivity and to promote learning via scaffolding, for example not only via 'smart' solutions such as Lecando's learning management system combined with CRMPA's Learning Intelligent Agent and CTAD's modular learning programmes, but also via Ultralab microportal facilities for asynchronous peer support and realworld mentoring.

8.3 Need driven, not technology driven

Whichever technologies are chosen for *m-learning* applications development, and whatever the product type, it is reasonable to assume that, for these applications to succeed, they will need characteristics which are attractive to the target audiences.

A good way to find out what young TA adults might want from *m-learning* applications, is to adopt a social-constructivist pedagogy here also, engaging TA members as co-researchers.

8.4 Interim summary and conclusions for m-learning

8.4.1 Need for debate

As web-enabled devices become more affordable, their development as learning tools becomes increasingly viable. Our need is to build a rich variety of m-learning resources that can accommodate differing learning paradigms, and that creatively exploit what makes mobile devices unique.

Computers are powerful mind tools, increasing in complexity, but with an interface which presents an illusion of simplicity, allowing us to interact with the computer - and to control it. An essential issue in interface design: how can we make the interface more powerful and more empowering? Design problems range from the purely technical to the strongly political, these tensions underline a need to move towards a multidisciplinary approach in the design process – and an associated need for debate towards a shared pedagogy for m-learning.

8.4.2 A social-constructivist approach

An online community of practice can complement realworld debate with m-learning partners. Where online learning communities are linked to realworld learning events, they can be seen as learning ecologies. And these are underpinned by social-constructivist philosophy.

From a social-constructivist standpoint, it is proposed that the pedagogical value of successful *m-learning* applications will lie in the extent to which they are easy to use, are cost-effective and absorbing and can foster a culture of learning. This in turn depends on the extent to which they can exploit the nature of the Web, where a shift is perceived from supporting the individual to supporting relationships between individuals. *m-Learning* developers should accordingly design for interactivity, to promote virtual networked and collaborative learning.

8.4.3 Need driven, not technology driven

Whichever technologies are chosen for *m-learning* applications development, and whatever the types of application, it is reasonable to assume that, for these applications to succeed, they will need characteristics which are attractive to the target audiences. There is a need for a social-constructivist approach to field research also, engaging TA members as co-researchers, to ensure products are need driven, not technology driven.

9 Executive summary and recommendations

9.1 Infrastructure, coverage

9.1.1 Traffic management

Importance of IPv6 and Broadband

Users of mobile services may experience network-related delays; these may occur in routing data via the IP suite or where bandwidth capacity is affected by delays in processing network data. High-speed protocols GPRS and new traffic management protocol IPv6 will effect improvements and should reduce SMS delay (important for Target Audiences). IPv6 still lacks 'killer applications' (an opportunity for *m-learning* here) and does not

yet offer the range of features users have with IPv4. Quality of service is still hard to deliver even with IPv6, as IP is inherently a connectionless protocol not suited to real time data like video and voice.

Important for m-learning: Ipv6 swings the axis of control of the infrastructure towards common good and public service organisations and is a significant contributor to the EU push for open source and non proprietary software environments.

Broadband means higher bandwidth, but has suffered from the poor investment climate. Change may come with video-on-demand and mobile professionals' need for flexible access to rich data; the main limiting factor is cost. Of key interest to m-learning is the significance of symmetry in bandwidth, in Ultralab experience it is a key component of a broadband learning environment as learners put in and contribute rather than simply download and interact. This skews broadband for learning away from ADSL towards other more symmetrical DSL technologies (VDSL for example).

Cost issues:

Relevant to ICT 'have nots' are the new Internet services for wireless Web-enabled phones, laptops and Personal Digital Assistants (PDA's), enabling these to act as modems. However bidding for mobile phone licences has led to spiralling costs and could ultimately make high speed access to the Internet too expensive for ordinary people, thereby widening, not narrowing, the digital divide that *m-Learning* potential users may have to bridge; m-learning managers should regularly re-negotiate business tariffs.

Roaming will be important for m-learners, not least if they want to widen their scope of peer support and mentoring, but is still problematic. For example: a 'tri-band' phone is needed for some countries and differences in billing systems between the US and the rest of the world can lead to reluctant roamers.

9.1.2 Transportability

Need for multi-platform support

A changing network scene brings a need for multi-platform support; network managers must aspire towards seamless interoperability. After software compatibility, security, and network management, managers should investigate the capabilities of different networks for their inherent transportability.

'2.5G' or 3G?

3G promises data rates of 2mbps – however implementation is slow. '2.5G' networks such as EDGE with data rates between 115 kbps and 384 kbps are a good short-term solution and a likely choice for cell phones for the next few years. Developers should keep in touch with broader 'Open Mobile Architectures' and grid computing developments, though these are likely to remain 'niche' technologies for the foreseeable future.

Future networking technologies

4G is being designed to cater for any shortcomings of 3G but implementation depends on a range of factors and is many years hence; eventual implementation is likely via phased migration paths, allowing managers to replace or upgrade existing technology at their own pace, for example via upgrading to Voice Over IP (VOIP) in combination with traditional phone services.

9.1.3 WLANs, messaging middleware

WLANs support real-time access environments via synchronisation technologies such as Bluetooth: 'computer carts' can be wheeled from room to room as needed. Public 'hotspots' or booths offer alternative ubiquitous computing models. Both solutions offer good dial-up connection. Bluetooth's principal limitation is its range (10 metres maximum); designed for adjacent devices, Bluetooth struggles to deliver 'across the room' performance making it a frustratingly 'nearly enough' technology to use.

Messaging middleware

The legacy messaging solutions that worked for client/server will not adapt to a web-centric model, hence a new generation of messaging solutions. These new technologies are web-native, firewall friendly and easily function with browsers as well as server applications. They promise lower costs and time to market, from web standards. Issues for managers to consider:

- Support for heterogeneous systems.
- Ability to add new topics, filters, transforms, etc dynamically, without requiring an administrator to recompile and redistribute code.
- A true internet-style routing model, so that multiple organisations can manage local user populations without central coordination and can scale both operationally and administratively.

Platform neutral, connecting existing and emerging technologies and resolving Microsoft and J2EE Platform incompatibilities.

Educational benefits and drawbacks:

WLANs and mobile middleware enable mobile device users to download / upload information and applications, with the potential to enhance collaborative learning and facilitate new teaching methods.

The downside: Ultralab's wireless research found significantly that where learners were physically connected to LAN, teachers would describe their students as being "very capable with the technology", but when the learners worked within a wireless environment the teachers simply described them as being "very capable..." The learner was empowered in unexpected ways - this translated into tougher questions and more ambitious tasks being set by the teacher, which in turn led to more rapid progress by the learners. Current Ultralab media rich environment project in Singapore shows that the wireless environment allows a greater integration between discrete curriculum areas (for example science and art).

9.2 Limitations of mobiles: key problems and emerging solutions

9.2.1 The constraints of handhelds

Desktop applications are usually unsuitable for wireless handheld devices; smart phones can't display large colour graphics or support point-and-click navigation although there is a very clear move towards MMS and other image and sound based messaging and interfaces. The problem is currently that image based services are perceived as a premium rate activity; those who may benefit most immediately from their adoption are likely to be excluded by pricing in the short term.

Developers may need to rewrite applications to accommodate these constraints, e.g. design for a small, low-resolution screen with a single window. At the same time we should be ambitious for the future and plan for MMS and also for integration of speech recognition further down the track.

9.2.2 Improvements to user interface

As the PDA and the cellphone merge, small high resolution, daylight viewable, tactile screens become rapidly affordable as economies of scale impact on costs. New chips afford higher access speeds.

Emerging solutions for data entry include integrated keyboards such as those offered by Handspring and Blackberry and pen handwriting recognition, set to be supported by a broad range of "tablet" type personal computers. Unfortunately, for many of the devices, the handwriting / keyboard input option is modal rather than parallel. Though implementation is likely to remain slow, the use of speech recognition is of

great interest: in Ultralab's mobile based assessment project, advanced use of speech to text technology allows learners to generate a full textual transcript from a lengthy spoken viva using mobile or other digital phones.

2.2.3 The identity debate

The Internet handles identity rather poorly: a key battleground in future technologies will be the struggle for control and ownership of the identity servers so crucial to social and learning interaction with Microsoft's Passport and open source solutions (eg Liberty Alliance) lining up head to head.

At Ultralab we are clear from a broad range of on-line community projects that public resolution to this identity problem is a key requirement which is likely to be addressed by a parallel need for identity cards.

9.3 Programming issues

9.3.1 Evolving protocols

Long accepted as a de facto standard, WAP was over-hyped and users were disenchanted with the so-called 'mobile internet'. User experience is set to change with consumer-centric 'push' technologies, but WAP's future is uncertain; it is now one of several competing standards that continue to evolve. XML, Java and freeware are among alternatives of strong interest to programmers.

9.3.2 Using 2.5G and 3G – designing for embedded systems

2.5G and 3G wireless systems support multimedia capabilities and also applications common to PDAs. A phased migration towards 3G is recommended. However most wireless applications developers however will be drawn from PC environments and will be unused to the new types of embedded platforms.

Designing for embedded systems means catering for different media transmission rates, limited processing power - narrow data bandwidth compared with wired networks. Developers are advised to improvise, for example where possible offload to the network and return control to the OS to keep power consumption low. Free toolkits are available via the internet, for example XcelleNet has a free 10-user licence.

3G phones will be able to receive colour video transmissions and high-quality music, however users may find large files too costly to download. A solution is to offer short video/audio clips of 10 to 15 seconds as previews, encouraging people to download the full product at home through their PC or TV.

9.4 New generation mobile devices - issues

New generation phones and hybrid PDA's are emerging, with more bandwidth and speed to transfer data. Increasingly, handsets are turning into 'world phones or 'microbrowsers', capable of dealing with the Web, receiving and sending e-mail, as well as storing MP3 files and other data. High screen resolution allowing you to view full-page width documents e-mails and Web pages without horizontal scrolling, together with significantly more processing power, afford more options to m-learning developers.

Data entry continues to pose problems; interesting solutions are integrated keyboards such as those offered by Handspring and Blackberry, but people may not want these cut-down PCs. Short-range radio technologies like Bluetooth make it easier to exchange information between devices, but en route you are unlikely to have more than one device with you.

Camera based phones can contribute to authentic learning, by offering an environment supporting media redundancy and by providing a non notational solution to mapping individuals milestones and progress. Their significance should not be underestimated.

9.5 Smart Web applications

9.5.1 The Semantic Web

The Web is set to become a Learning Network through smart Web applications, built with adaptive software languages and connected by Web Artificial Intelligence (AI) Service Portals, and using components of AI agents.

9.5.2 New email and groupware solutions

Potential for m-learning

Wireless email and groupware for business professionals have obvious potential for m-learning implementations. Email engines cater for popular platforms such as BlackBerry, PalmOS, smartphones and Pocket PC. Currently however cost considerations may inhibit use.

Choice of access environments

Real-time access environments allow users continuous connection to the server: data is viewed as it is entered with no local storing of data or applications. In asynchronous environments, data and applications are downloaded from the server and can be stored on the devices. Users are freed from the vagaries of network status or available bandwidth: data is updated locally and at server via synchronisation sessions. These technical benefits, plus reduced queries and 'user idle time' and controlled

communication costs, make them a good choice for m-learning applications.

Choice of groupware server

A groupware server should support leading backend messaging platforms such as Lotus Notes and FirstClass. However the interests of equity investors may affect the levels of support given to networks: consumers need to be wary of this.

Market trends

Consumer email and consumer m-commerce have still not really taken off in Europe. Until the security issues of end-to-end encryption and authentication are seen to be resolved, m-commerce services may not attract enough users to make them profitable. Negligible revenue for most carriers is expected shorter term and *e-learning* companies may find that it is more difficult to make money selling products and services via mobile phones than it is via the fixed-line internet.

Potential growth areas include location-based m-commerce and wireless advertising, although TA users may not want random advertisements popping up on their mobile phone. Wireless email and groupware will be more important for *m-learning* in the foreseeable future; so too will messaging, mobile games and music, as will be seen below.

9.6 Text messaging, multimedia messaging and mobile games

9.6.1 Mobile games, SMS and MMS have obvious potential for *m-learning* implementations:

- WAP 2.0 push technology is attractive, with the potential for supporting interactive learning. Youth interest in games can be supported via WAP in-built networking capability and freeware/open-source products.
- SMS is more than just a passing fad, it is a communication medium integral to young people's lives, whereby cost remains an issue. The asynchronous nature of SMS is key to its phenomenal success.
- There is a very clear move towards MMS and other image and sound based messaging and interfaces.

Field research is needed to see how much the newer and more expensive Web-enabled phones, MMS and music technologies will appeal to TA users. 'Just a phone' - that can use SMS - may still prove to be what they want most. The problem is currently that image based services are perceived as a premium rate activity; those who may benefit most

immediately from their adoption are likely to be excluded by pricing in the short term. If so, we must design applications with this in mind, while at the same time remaining ambitious and seeking to engage TA audiences via the new technologies – on past performance cost is likely to come down over time.

We should investigate how far voice navigation and unified messaging are likely to be important, as well as the ability to create learner profiles, for example so that tutors/mentors can use them to engage with learners on a personal level.

9.7 Towards a pedagogy for m-learning

9.7.1 Need for debate

As web-enabled devices become more affordable, their development as learning tools becomes increasingly viable. Our need is to build a rich variety of m-learning resources that can accommodate differing learning paradigms, and that creatively exploit what makes mobile devices unique.

Computers are powerful mind tools, increasing in complexity, but with an interface which presents an illusion of simplicity, allowing us to interact with the computer - and to control it. An essential issue in interface design: how can we make the interface more powerful and more empowering? Design problems range from the purely technical to the strongly political, these tensions underline a need to move towards a multidisciplinary approach in the design process – and an associated need for debate towards a shared pedagogy for m-learning.

9.7.2 A social-constructivist approach

An online community of practice can complement realworld debate with m-learning partners. Where online learning communities are linked to realworld learning events, they can be seen as learning ecologies. And these are underpinned by social-constructivist philosophy.

From a social-constructivist standpoint, it is proposed that the pedagogical value of successful *m-learning* applications will lie in the extent to which they are easy to use, are cost-effective and absorbing and can foster a culture of learning. This in turn depends on the extent to which they can exploit the nature of the Web, where a shift is perceived from supporting the individual to supporting relationships between individuals. *m-Learning* developers should accordingly design for interactivity, to promote virtual networked and collaborative learning.

9.7.3 Need driven, not technology driven

Whichever technologies are chosen for *m-learning* applications development, and whatever the types of application, it is reasonable to assume that, for these applications to succeed, they will need

characteristics which are attractive to the target audiences. There is a need for a social-constructivist approach to field research also, engaging TA members as co-researchers, to ensure products are need driven, not technology driven.

Alice Mitchell
Ultralab, July 2002

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(Lots of information plus the full standards)

CISCO Systems: *Wireless LAN Security Overview*, 2001
http://www.cisco.com/warp/public/cc/pd/witc/ao350ap/prodlit/a350w_ov.htm
(Identifies problems and highlights CISCO's proprietary solution)

Borisov N *et al*: *Intercepting Mobile Communications: The Insecurity of 802.11*, in Proceedings of MOBICOM 2001, 2001,

<http://citeseer.nj.nec.com/borisov01intercepting.html>

(Exposes security flaws in the 802.11 standard, e.g. use of a initialisation vector of only 24 bits)

Dell Vector: *802.11 Wireless Security in Business Networks*,

http://www.dell.com/us/en/bsd/topics/vectors_2001-wireless_security.htm

(Introduces some of the problems and highlights possible solutions)

Misra A & Arbaugh W: *An initial security analysis of the IEEE 802.1x standard*, University of Maryland CS-TR-4328, 2002 <http://www.cs.umd.edu/~waa/1x.pdf>

(Exposé of a major flaw in the 802.1x standard. Fairly technical.)

Education and Youth

Berger C: *Wireless: Changing Teaching and Learning “Everywhere, Everytime”*, Educause Review, Vol 36 No 1, 2001,

<http://www.educause.edu/ir/library/pdf/erm0116.pdf> (Concerns wireless use, includes information on computer carts)

The Gallery of courses taught with Technology <http://iccel.wfu.edu/gallery/>

(Postings on how people are using technology to enhance teaching and learning. Quality of entries varies)

Palm: *Penn State Abington Students Use Palm Handhelds for Collaborative Learning*, <http://www.palm.com/education/studies/study10.html> (A case study)

Appendix: Glossary and Acronyms

Revision History

Date	Version	Description	Author
24/6/2002	1.1	Working document	Alice Mitchell
9/4/2002	1.2	Terms added, formatting	Alice Mitchell
3/09/2002	1.3	Terms added	Alice Mitchell

This list offers working definitions for terms used in Ultralab documents produced for *m-learning* which may be unknown to the reader. The list complements the Technology Watch report and will be updated and expanded on an ongoing basis throughout the lifetime of the project. Sources of information include Web glossaries such as those available at:

<http://hotwired.lycos.com/webmonkey/glossary/api.html>

<http://foldoc.doc.ic.ac.uk/foldoc/index.html>

<http://webdesign.about.com/library/glossary/bldefdhtml.htm>

<http://manuel.brad.ac.uk/help/.xferfile/.glossary.html>

<http://cellphones.about.com/library/glossary/blglossary.htm>

Glossary

2G

Second generation mobile telephony protocols still in current use around the world. They include GSM and support high bit rate voice and limited data communications. Auxiliary services include data, fax and SMS.

2.5G

These extensions of 2G protocols to provide packet-switched connection (GPRS) and enhanced data rates such as EDGE.

3G

3G = third generation of wireless communication technology: a generic term covering a range of emerging wireless network technologies and claiming to support much higher data rates measured in mbits per second. 3G is intended for applications other than voice, e.g. data, motion video, video-conferencing and Internet access.

4G

A conceptual framework for a universal high speed wireless network that will seamlessly interface with wireline backbone network.

Accessibility

Provision via a universal text version without use of frames, tables, or visuals.

Active learning

A process of learning new ideas, skills and attitudes through doing, performing, and taking action. The action can be either mental (e.g. reflection) or physical (e.g. a case study). Active learning makes use of devices such as games, simulations, introspection, role playing, etc.

AICC

Aviation Industry CBT Committee (AICC): offers certification re. compliancy with AGR 010, the AICC guideline for web-based computer-managed instruction systems.

Aptitude

The ability of a person to acquire a new skill or to demonstrate the potential for acquiring a skill when given the opportunity.

Asynchronous learning

A learning event that is delivered after the original live event, where the interaction is delayed over time.

Authoring tool

Software application used to produce media-based content.

API

Application Programming Interface - enables programming to a pre-constructed interface (the API) rather than directly programming a device or piece of software, thereby allowing for faster development without need for detailed knowledge of the device / softwares you are sending commands to.

Application Server

Supports Web-based applications which link end users to corporate databases. Acts as a go-between between web browser and database server; there is no need for high-maintenance Windows applications at user end.

Authorisation

Software tools assigning access and other privileges to designated users/groups.

baud

Unit of measurement for the information carrying capacity or "signalling rate" of a communication channel.

BBS-file-exchange

Bulletin Board Service: facility for downloading and uploading files over the Internet.

Bluetooth

High-frequency radio transmission technology, allowing high-speed data transfer between Bluetooth-enabled devices - laptops, mobile phones, network access points and other devices - within a short range (10 m).

Bit

Unit of information obtained by asking a yes-or-no question.

Bookmarks

Bookmarks identify internet locations and this category covers the creation, display, management and updating of bookmarks.

Buffer

Area of memory used for storing messages. Typically has input and output pointers and/or a count of the space used or free. Buffers decouple processes to enable the reader and writer to operate at different speeds /on different sized data blocks.

Byte

The smallest addressable unit of storage, usually eight bits.

Convergence technologies

Technologies such as *Bluetooth* which permit convergence between devices.

Cookies

Small amounts of structured data that are shared between a World Wide Web server and the user's browser, giving the server information about a user's identity, preferences or past behaviour. Cookies utilise forms that users may fill out on a Web site that supports them. Not every browser supports cookies.

Denial-of-service attacks

Floods of data packets can be used to overwhelm servers and choke access to the sites; after scanning remote machines for vulnerabilities, attackers secretly load software that uses the compromised servers as agents in attack networks that are then harnessed against targeted sites.

Chat

Chat includes facilities like Internet Relay Chat IRC and similar text exchanges.

Cambridge Training and Development Agency (CTAD)

A project partner, CTAD is a commercial organization developing very small literacy and numeracy modules for the *m-learning* project.

Ethernet

A local area network where data is broken into packets and that is specified as IEEE 802.3, now recognised as industry standard.

Firewalls

Hardware and/or software lying between two networks, such as an internal network and an Internet service provider. The firewall protects the network, blocking unwanted access and disallowing messages to specific recipients outside the network, e.g. competitors.

GPRS

General Packet Radio Services: a packet-based wireless communication service, promising data rates from 56 to 114 Kbps plus 'always on' connection to the Internet.

GSM

Global System for Mobile Communications: a 2G standard widely adopted in Europe because of its international roaming capability. Sometimes known as 'Go Slow Mode'.

Handheld

Small battery operated personal computer designed to fit in the hand; input devices: keyboard, stylus.

Handshaking

Predetermined hardware/software activity to establish/maintain two machines or programs in synchronization, e.g. the exchange of messages/data packets between two systems with limited buffers.

Hotspot

Public kiosk/display that allows users to access the Internet, for example via touchscreen.

Internet Protocol Security (IPsec)

A suite of protocols for secure private communications over the Internet, IPsec proposes a standard platform for secure IP connections on private networks.

Internet Service Providers (ISP)

ISPs link people and businesses to the Internet. Most offer the same data delivery and sending services, but services and performance vary widely. Large providers connecting to national backbones have faster network connections and deliver traffic through fewer router hops than local providers.

IMS

A global coalition with headquarters in Burlington, Massachusetts and consisting of over 250 technology vendors, developers, educational institutions, and

government agencies. IMS Specifications are XML-based, open standards allowing providers to re-use education and training resources among online learning systems from different vendors. Home page at <http://www.imsproject.org/>

Intrusion Detection System (IDS)

An intrusion-detection system monitors system and network resources and activities, senses when a system or network is being used inappropriately or without authorization, then notifies the authorities of a possible intrusion.

IP

Internet Protocol: a set of standards allowing 2 or more computer devices to share information across a network.

Java

A programming language developed by Sun Microsystems that creates code for interactive applications that is executable on web pages by web browsers. These Java applications can execute on any platform: Macintosh, PC, and so on.

'Just in Time'

A term used to describe a system or information that is available for the user at the exact time the user needs it.

Kerberos

A network authentication protocol exchanging encrypted messages from one computer to prove its identity to another across an insecure network. After verifying identity, Kerberos provides the encryption keys for secure communication session.

Layer 3 switching

Emerging technology where high-speed routing is built in to LAN switches.

Advantages of Layer 3 routers:

- switch off-load tasks such as IP routing
- can route faster than Layer 2
- cost less than high-end routers

Lecando AB

A Sweden commercial company, part of a group with an international reputation for expertise in advanced speech and language technologies; an *m-learning* partner.

MeT

An initiative which establishes a framework for secure mobile transactions, aiming to ensure a “consistent user experience independent of device, service and network”. <http://www.mobiletransaction.org/#>

Microportal

The standard definition of a microportal on the web is two-fold. One definition is a single page with a list of links, usually created by one person, which covers a specific purpose or area of interest. The other definition is an extension application or plugin for a web browser which adds to its navigation functionality to point to a specific type of content or features of a specific place.

Other definitions for standard portal systems include horizontal, vertical and enterprise ports:

- Horizontal portals are web portals which in some way track the preferences of the user. This can be done automatically or it can be done via some kind of preferences screen where the user can include bookmarks and enter settings.
- Vertical portals are sites which cover a specific area of interest - so you may have a portal through to lots of sites on financial information - stock markets for instance, these are sometimes in the category of downloadable plugin microportals;
- Enterprise portals are company portals - the Microsoft© web site could be described as a company portal.

Standard web portals are hierarchical sites, usually categorised by subject linking through to sites of interest. All portals have a search functionality.

ML World

ML = microportal layer, and is a temporary designation. ML World is the concept of a prototype online role-play game to be explored by the m-Portal development team. Any role-play version of the system will deploy higher level technology.

MMS

Multimedia Messaging Services – the next generation of messaging. Does not utilize the SMS protocol and provides a format that can deal with complex media and is more interoperable.

m-Portal

m-learning outcome: a microportal layer which allows the participants in the m-learning system to create their own microportals with the additional benefit of having the system create the microportal for them, if desired, based upon their activity in m-learning. Other functionality of m-Portal to be iteratively developed during the project.

m-Portal Constructor

First access point to *m-Portal*, where preferences can be set and links to things of interest can be chosen or inserted by users.

m-Portal Co-researcher

The co-researcher is a Target Audience respondent who works voluntarily with

the Field Research team and contributes to *m-Portal* iterative design and development.

m-Portal Deployment

Ensuring that the microportal prototype is available for use by project partners and members of the target group.

m-Portal Elaboration/Construction

The alpha phase of the m-Portal development process:

- m-Portal vision and architecture are refined. The prototype system's requirements are articulated and prioritized in consultation with project partners via WPs 6, 7 & 8.
- m-Portal prototype is iteratively developed to the stage where it can be alpha and beta tested respectively. This implies describing the remaining requirements and acceptance criteria, fleshing out the design and completing the implementation and testing of the software. The system's requirements and its evaluation criteria are constantly re-examined against the needs of users and resources are allocated as appropriate to actively attack risks to the project.

m-Portal End phase

m-Portal undergoes User Trials. Even during this phase, the prototype system is continuously improved, bugs are fixed, and features that didn't make an earlier release are added.

m-Portal Field research

Activities undertaken individually and collaboratively to collect data from members of the target audiences concerning their needs and preferences relating to project aims and objectives in order to inform iterative m-Portal development.

m-Portal Inception phase

The pre-alpha phase of the m-Portal development process. An exploratory phase which seeks to identify user requirements and project feasibility. Outcome is a conceptual design, taking into account the emerging findings of initial field and desk research, and partners' needs.

m-Portal Iterative Design and Development

m-learning microportal (m-Portal) requirements are defined and redefined as they are derived from an ongoing programme of field and desk research and from liaison with partners, into a robust microportal design; to adapt the design to cater for the needs and preferences of the target audiences and to match the implementation environment, designing it for performance.

m-Portal Requirement

What functionality and characteristics the prototype system should have, whereby the focus is on the needs and goals of the users, i.e. members of Target Audiences, and the *m-learning* partners. The requirements inform the development of the system, establishing boundaries and affording a basis for costing and resourcing the system.

Multimedia

A very general term that usually refers to computer programs that use a combination of sound, video, animation, pictures, and/or text.

MVNO

A Mobile Virtual Network Operator, such as Virgin Mobile or T-Mobile, provides a mobile carrier service without actually owning or maintaining the physical network.

ODBC

Open Database Connectivity - a standard API (Application Programming Interface) for communicating with database servers. Different ODBC drivers support most major database servers, such as Oracle and Microsoft SQL Server. Programming to ODBC means being able to easily use an application on different databases without reprogramming.

Packet

A generic term used to describe a unit of data sent across a network at any layer of the OSI protocol stack, particularly application layer data units.

PDA

Personal Digital Assistant, also referred to as Palmtop or Handheld computer. Manufacturers include Palm, Handspring, Psion and Sony.

Point-to-point tunneling protocol

A means of encoding information for transmission across networks which use the Internet Protocol. Originally a means of letting remote users dial in to a network, it can also connect one local network to another via the Internet in 'a virtual private network'.

Protocol

A set of formal rules defining how to transmit data, e.g. across a network. Low level protocols define the electrical/physical standards, bit- and byte-ordering, transmission and error detection and correction of the bit stream. High level protocols define data formatting, terminal to computer dialogue, character sets, message sequencing, etc.

Proxy Servers

A server which controls client computer access to the Internet, thereby:

- controlling employees' access to Web addresses improving performance via local storing of Web pages
- protecting the internal network's identity.

RSA security

A public-key encryption system, RSA is increasingly used for document security and user authentication.

Simple Object Access Protocol (SOAP)

SOAP is the message protocol that allows Web services to talk. Originally released in April 2000 by IBM and Microsoft, and now a project of the, *SOAP* codifies the existing practice of using XML and HTTP to invoke methods on servers, services, components and objects.

Server security

Security tools are used to prevent unauthorized access and/or modification of data. This can include a wide range of approaches and methods.

Smart phone

A wireless phone with text and Internet capabilities which can:

- handle wireless phone calls and voice mail
- send and receive E-mail and fax transmissions.
- hold addresses
- access information on the Internet

SMS

The Short Message Service enabling users to send and receive text messages from a mobile phone. Text can be words, numbers or an alphanumeric combination.

SMS-JDK

SMS-JDK is a pure Java implementation of the protocols used to connect to the world of short messaging. In brief, it supports the SMSC protocol (professional version), cellular device, generic API, synchronous or asynchronous sending/receiving, smart message, long message and enhanced SMSC protocol. With these features, the server is able to 'push' the information to users and users can 'pull' the information from the server.

SQL

Structured Query Language: type of relational database where data is in rows and columns: each row represents a record, each column is a field. Most serious database solutions today use some form of SQL to store and access large quantities of data quickly and reliably.

Tag

Term used in Html and XML - symbols/words bracketed by '<' and '>'

Target Audiences

Target Audiences are young adults in the age range 16-24 who are not in formal education or training environments and who have literacy or numeracy skills development needs. These young adults may be mobile, in casual/temporary employment, self-employed or in low paid/low skill employment, or unemployed.

Test

Verifies the interaction between objects; to verify the proper integration of all components of the software; to verify that all requirements have been correctly implemented; to identify and ensure defects are addressed prior to the deployment of the software.

VoiceXML

Like Extensible Markup Language (XML), but lets you convert an existing document into speech.

User

A Target Audience member; a member of a partner *m-learning* organization; a critical friend.

User testing

A phase stage whose purposes are to obtain feedback from users, to verify that requirements have been correctly implemented; to identify defects and ensure these are addressed prior to final release of the prototype.

Ultralab

A learning technology research centre based at Anglia Polytechnic University; an *m-learning* partner.

WAP

The Wireless Application Protocol (WAP): a set of specifications, developed by the WAP Forum so that developers using Wireless Markup Language (WML) can build networked applications designed for handheld wireless devices. WAP design works within the constraints of these devices:

- limited memory and CPU size
- small, monochrome screens
- low bandwidth
- erratic connections.
- Support from more than 200 vendors makes WAP *de facto* standard.

Web Services

The middleware between network and e-business application.

WiFi

A standard for wireless networking from the Wireless Ethernet Compatibility Alliance (WECA).

WML

Wireless Markup Language

Word

Basic unit of storage in a computer.

WYSIWYG

What you see is what you get

xDSL

A family of digital telecommunications protocols designed to enable high speed data communication over existing copper telephone lines between end-users and telephone companies.

XML

A W3C method for putting structured data in a text file: produces files that are easy to generate and read by a computer, in ways which are unambiguous and avoid common pitfalls, such as lack of extensibility, lack of support for internationalisation/localisation and platform-dependency. The XML text format is verbose, but this is fast becoming less of a problem with cheaper disc space and improved compression programs - modern protocols can compress data on the fly - the advantages of XML easily compensate for any disadvantages. Like Html, XML makes use of tags and attributes (names) but are text files, making it easier to debug applications. However a forgotten tag or incomplete attribute makes the file unusable (in Html such errors are often tolerated).

XML is a family of technologies, which are fast developing; their development goes back to the early 80's. XML is licence-free, platform independent and well-supported.

Acronyms

2G	2 nd generation technology
2.5G	intermediate technology between 2G and 3G
3G	3 rd generation technology
4G	4 th generation technology (a conceptual framework)

AI	Artificial Intelligence
APDU	application protocol data unit
API	Application Program Interface
ART	Advanced Recognition Technologies

bps	bytes per second
BT	British Telecom
CCD	Charged Couple Device
CDMA	Code Division Multiple Access
CIDR	Classless Inter-Domain Routing
cHTML	Compact-HTML
CMOS	Complementary Metal Oxide Semi-Conductor
CPU	Central Processing Unit
DBMS	Database Management System
DSL	Digital Subscriber Line
EDI	Electronic Data Interface
EIP	Enterprise Information Portal
ETSI	European Telecommunications Standards Institute
FTP	File Transfer Protocol
Gb	1000 bits per second
GPRS	General Packet Radio Service
GHz	Giga Herz
GSM	Global Standard for Mobile Communication
HTML	Hypertext Mark-up Language
HDML	Handheld Device Mark-up Language
HSCSD	High Speed Circuit Switched Data
HTTP	Hypertext Transfer Protocol
KHz	Kilo Herz
ID	Identification
IDS	Intrusion Detection System
IEEE	Institute of Electrical and Electronics Engineers
IM	Instant Messaging
IP	Internet Protocol
IR	Infrared
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
J2ME	Java 2 Micro Edition
kbps	kilo bits per second
LAN	Local Area Network Access Protocol
LBS	Location-Based (or Location-Specific) Services
LDAP	Lightweight Directory Access Protocol
MB	Megabits
Mbps	Megabits per second
MHz	Mega Herz
MMAC	Multimedia Mobile Access Communication
MMS	Multimedia Messaging Services
MVNO	Mobile Virtual Network Operator
NAT	Network Address Translation
OFDM	Orthogonal Frequency-Division Multiplexing
OS	Operating System
OSI	Open Systems Interconnect

P2P	Peer-to-peer
PC	Personal Computer
PDA	Personal Digital Assistant
PIM	Personal Information Manager
PIP	Personalised Information Portal
PKI	Public Key Infrastructure
RPG	Role-Play Game
SIM	Society for Information Management
SIP	Session Initiation Protocol
SMEs	Small - Medium-sized Enterprises
SMS	Short Message Service (acronym also used by Microsoft for their Systems Management Server)
SOAP	Simple Object Access Protocol
TCP	Transmission Control Protocol
TCP/IP	General name given to the IP protocol suite
TDMA	Time Division Multiple Access
UDP	User Datagram Protocol
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
UWB	Ultra Wideband
VOIP	Voice Over IP
VPN	Virtual Private Network
WAN	Wide Area Network
WAP	Wireless Application Protocol
WEA	WebSphere Everyplace Access
WECA	Wireless Ethernet Compatibility Alliance
WLAN	Wireless Local Area Network
WML	Wireless Mark-up Language
WPAN	Wireless Personal Area Network
WWAN	Wireline Wide Area Network
XHTML	a hybrid of XML and html
XML	Extensible Markup Language