9. USABILITY AND USER INTERFACE DESIGN CONSIDERATIONS

9.1 Usability and QoS Testbed Design

The model of a multimedia Walkman needs to be validated based on the feedback obtained from end-users. At first, the basic features need to be tested by a group of test persons in a PC-based testbed, simulating the operation of a multimedia Walkman operation. Since we are interested in user behavior in the first place, we need not necessarily implement all the support functions. As a matter fact, it is adequate to create such conditions, which resemble as much as possible the real operation. By simulating the functions, the testbed becomes simpler and most of the software can run on a powerful desk-top PC, which is controlled by a researcher acting as the tester. The user and the tester are in adjoining rooms during the test. This approach allows us also to make the user equipment fairly simple and lightweight. However, local intelligence is needed to some extent, which may be provided by a PC104 or PC110 computer. The user interface should be as close mock-up as possible of a real implementation.

Soon there will be MMX versions of PC104 and PC110 in the market, with enough power to accomplish even more sophisticated tasks in the simulated MMW environment. Even a MMW mock-up implementation contains new I/O technology, which needs to integrated into a low latency, user-friendly entirety. At a later stage, the mock-up is suggested to be upgraded into a prototype implementation, capable of operating over a real GSM multi-slot air interface.

The most important user interface devices representing the essential media components are:

- an ear-piece microphone combination
- a head-mounted miniature display with at least VGA resolution
- speech recognition software with a reduced command set
- a remote control unit
- software for multi-modal integration.

The devices the user is supposed to wear during the tests are interconnected across a high speed digital parallel link to a desk-top PC. In addition to the payload, a digital control channel is required to transfer data between the user equipment and the PC bus. Since, most of the digital speech and video processing is planned to take place in the PC, the operation of the user processing devices are limited to such functions as D/A and A/D conversions transforms and I/O controls.

It is recommendable that the high-speed data link between the user equipment and the server is cordless to create an authentic feeling, but this would complicate the design substantially. Nevertheless, a cord, in case such exists between the user and the central testing facility, should be as unobtrusive as possible from the user perspective. An infrared serial link is probably the simplest cordless alternative, but it restricts the movements of the user.
The head-mounted miniature display is driven from a display controller or a H.263 video codec located in the desk-top. For speech, a G.723.1 speech codec will be used as a default codec, which is included in Microsoft’s Netmeeting, but at a later stage, GSM and G.729 speech codecs may be used as well.

In parallel with the user interface and usability issues, we aim at studying the influence of some QoS parameters. Since speech quality has been studied extensively elsewhere already, while less attention has been paid on video quality of low bit-rate systems and various delays affecting the response times as seen by the user, we intend to concentrate on the latter QoS issues. The influence of packet loss on both speech and video quality needs to be studied as well. The simulation of packet losses and errors is fairly simple.

Figure 1 Suggested testbed architecture
As a conclusion, the testbed should support testing of the following QoS parameters:

- post selection delay (seconds)
- terminal negotiation delay (seconds)
- time to provide service or mean access delay (seconds)
- overall delay for speech/speech + video (milliseconds)
- bit errors (BER)
- byte loss (bytes/min.) simulating packet loss in regard to video quality

It is important that the testbed allows testing of separate entities and services of a MMW such as user interface and voice Web browsing by simulating those functions, which are not yet available at that point of time. The user preferences and requirements of QoS can be investigated by running simulated services in the testbed with various types of QoS parameters. After the simulated tests, tests in real operational conditions can be carried out. This implies that in the long term, the process of designing and setting up the testbed is a continuing one. Gradually the ultimate target is a powerful testbed, capable of running a wide variety of services and applications in a real MMW terminal environment and in which simulated functions are replaced with those of real operational conditions. End-user involvement in the design process is also essential.

In terms of usability testing in phase 1, speech, voice recording, Web browsing and e-mail should be supported as a minimum requirement. For Web browsing, response times should be programmable as well as call setup delays. Furthermore, video can be included in phase 2 by using SW based H.323 implementations such as NetMeeting. Furthermore, Microsoft’s ActiveX technologies enable inclusion of multimedia effects into Web browsing. For instance voice Web browsing can be first simulated the tester acting as a help-desk operator, should be programmable as well.

9.2 User Interface

The big question is the user interface itself. Do users accept a head-mounted display, in particular together with speech recognition and a remote controller? The answers are tightly bound in the implementation of the test user interface. The implementation should allow flexible modifications based on the user feedback at least in limited scale.
Even for a mock-up, test user interface design and related multimodal integration is a challenging task. Voice recognition SW packages are available from several vendors, but the remote controller has to be implemented from a scratch. A simple keyboard is needed mainly for e-mail messages. Since they are usually fairly short, a chording keyboard may be adequate, regardless of its low typing speed. This is one of the issues that needs to be tested. Through multi-modal integration, the typing speed and the user-friendliness of the user interface may be increased compared to those currently used in cellular phones. Multimodal integration is one of the challenges faced in the user interface implementation. Another interesting matter is simultaneous operation of a remote controller when viewing a head-mounted display. In general, users attitudes towards a head-mounted display is a key question.
10. CONCLUSIONS

We have characterized in this investigation the new paradigm of mobile communications by introducing a virtual model of *personal multimedia communication space*, which integrates Internet, World Wide Web, enhanced wireless data transfer capabilities, and mobile computing with personalized content. Personal multimedia communication space is built upon a scenario of a new terminal concept, multimedia Walkman™. The key technologies for such personal multimedia appliances are evolving rapidly and we believe that practical realizations are possible within 3-5 year time frame. A multimedia Walkman is only one scenario of many possible future wireless information appliances, mainly addressing the consumer market.

On the basis of our model, we have reviewed the impact of international standards on low bit-rate real-time multimedia communications with some basic consideration of system architectures. Furthermore, we have reviewed some marketing aspects through case studies and multimedia system architectures, in particular from International standards and quality of service point of view. Feasibility of wireless Internet telephony enhanced with real-time video over packet radio access has been assessed. It seems that the latency problem, faced in the wireline IP environments as well, becomes overwhelming. Moreover, QoS management of real time applications, run over low bit-rate error-prone packet radio channels, is much more difficult than in the fixed network. It is highly questionable whether such wireless real-time multimedia would gain user acceptance. Wireless networks lack also the cost incentive of the Internet. For this reason, plain voice-over-IP seems unrealistic. As a conclusion, we do not expect voice-over-IP to become a reality in short or medium term, except as an overlay to Web browsing. There is no proof yet that even this application is feasible in packet radio environments.

Evolution of wireless communications will be driven by the rapidly growing Chinese market, which is expected to become the largest one by year 2000. By its nature, this market is likely to leverage new digital technologies, which enable wireless local loops and low cost terminals, higher bandwidths, and cheaper call rates. Also the industrial countries, which share the need for high speed, low delay asymmetric data access to the Internet will benefit from the Chinese market evolution. Low-tier micro-cell environments fit best for terrestrial wireless multimedia applications. The problem of limited coverage will be solved with multi-mode transceivers.

The claims that exposure of the human body to RF power levels of existing cellular transceivers cause health risks may trigger a movement with serious consequences to the booming wireless industry. So far no convincing evidence is available, either for or against. This potential threat factor may give an additional thrust towards low-power wireless systems.

The main question related to our model reads: What are the user reactions and what kind of preferences and requirements they have. Since, answers to our questions will profoundly affect the architecture, extensive usability tests are needed in the first place. We have presented a tentative usability testbed concept. Our intention is to set up the testbed in the near future to validate our model and investigate user reactions to some essential QoS parameters.
# Taxonomy of Internet telephony and multimedia standards

[8/4/97, Christer Englund, ITC Consortium]

(An asterix denotes a draft standard, not yet available. Also many of the existing standards are being upgraded to extend the functionality)

## H.323 Terminal
- Internet telephony and multimedia terminal
- Speech coding: G.723.1
- Video coding: H.263
- System Control: H.245
- Security+encryption: H.235*

## ISDN
- Speech: G.723.1
- Video: H.263
- System Control: H.245
- Security+encryption: H.235*

## PSTN
- Speech & Video: UDP
- Reliable bitstream delivery: TCP
- Signaling: Q.931

## IP Networks (Intranet, Internet etc)
- Speech & Video: UDP
- Reliable bitstream delivery: TCP
- Signaling: Q.931

## Phy+link layer
- IEEE 802.3

## Transmission delay:
- G.114

## Speech terminal
- Subjective tests of speech quality and codec performance
  - P.800, P.830

## Guaranteed QoS LAN
- Speech coding: G.723.1
- Video coding: H.263
- Packetization and synch.: H.235*
- Time stamping, payload def.: RTP
- QoS, rate and session ctrl.: RTCP
- System Control: H.245

## Non-guaranteed QoS LAN
- Speech coding: G.723.1
- Video coding: H.263
- Packetization and synch.: H.235*
- Time stamping, payload def.: RTP
- QoS, rate and session ctrl.: RTCP
- System Control: H.245

## Gatekeeper
- Address translation
- H.225.0

## Gatekeeper (Multipoint Control Unit (MCU))
- H.323 Multipoint Control Unit (MCU)

## H.323 Gateway/IP Server
- Data protocols: T.120
- Supplementary services: H.450.X*

## H.324 Terminal
- Subjective tests of speech quality and codec performance
  - P.800, P.830

## H.320 Terminal
- Speech: G.711, G.728
- Video: H.261
- Synch: H.221
- Sys. Ctrl: H.242

## H.322 Terminal
- Speech: G.723.1
- Video: H.263
- Packetization and synch.: H.225.0
- Time stamping, payload def.: RTP
- QoS, rate and session ctrl.: RTCP
- System Control: H.245

## H.323/M Terminal (Annex C* of Rec. H.324)
- Speech & Video: UDP
- Reliable bitstream delivery: TCP
- Signaling: Q.931

## Regional Std such as GSM
- H.243
- MUX/DEMUX
- Error ctrl (Annex C)
- H.245, G.723.1, H.263
- Aggregation protocol: H.235*

## POTS Terminal
- P.48, Echo: G.131

## Directory services
- LDAP

## PSTN Echo cancel: G.165

## ISDN
- DTE/DCE protocol: V.8/V.8 bis
- Modem: V.34, V.25ter (ctrl)
- Other: H.245, H.223, G.723.1, H.263, H.Multiplexing*
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACR</td>
<td>Absolute category rating</td>
</tr>
<tr>
<td>A/D</td>
<td>Analog/digital</td>
</tr>
<tr>
<td>ADPCM</td>
<td>Adaptive differential pulse code modulation</td>
</tr>
<tr>
<td>ADSL</td>
<td>Asynchronous digital subscriber loop</td>
</tr>
<tr>
<td>AMPS</td>
<td>Advanced Mobile Phone System</td>
</tr>
<tr>
<td>ARQ</td>
<td>Automatic repeat (resend) request</td>
</tr>
<tr>
<td>ATM</td>
<td>Asynchronous transfer mode</td>
</tr>
<tr>
<td>AUC</td>
<td>Authentication center</td>
</tr>
<tr>
<td>BCH</td>
<td>Bose-Chaudhuri-Hocquenghem</td>
</tr>
<tr>
<td>BER</td>
<td>Bit error rate</td>
</tr>
<tr>
<td>BTS</td>
<td>Base transceiver station</td>
</tr>
<tr>
<td>BSC</td>
<td>Base station controller</td>
</tr>
<tr>
<td>CDMA</td>
<td>Code-division multiple access</td>
</tr>
<tr>
<td>CELP</td>
<td>Code excited linear predictor</td>
</tr>
<tr>
<td>CIF</td>
<td>Common interchange format (352x288 pels luminance, 176x144 chrominance)</td>
</tr>
<tr>
<td>CPU</td>
<td>Central processing unit</td>
</tr>
<tr>
<td>CRC</td>
<td>Cyclic redundancy check</td>
</tr>
<tr>
<td>CS</td>
<td>Circuit switched</td>
</tr>
<tr>
<td>CSMA/CD</td>
<td>Carrier sense multiple access/collision detection (IEEE 802.3 Ethernet protocol)</td>
</tr>
<tr>
<td>CSN</td>
<td>Circuit switched network</td>
</tr>
<tr>
<td>CTIA</td>
<td>Cellular Telecommunications Industry Association</td>
</tr>
<tr>
<td>DAVIC</td>
<td>Digital Audiovisual Council</td>
</tr>
<tr>
<td>DCR</td>
<td>Degradation Category Rating</td>
</tr>
<tr>
<td>DECT</td>
<td>Digital European cordless telecommunications</td>
</tr>
<tr>
<td>DRAM</td>
<td>Dynamic random access memory</td>
</tr>
<tr>
<td>DSD</td>
<td>Delay sensitive data</td>
</tr>
<tr>
<td>DSP</td>
<td>Digital signal processor</td>
</tr>
<tr>
<td>DCE</td>
<td>Data circuit-terminating equipment (a device that converts the DTE data into signals fit for the line, e.g. a modem)</td>
</tr>
<tr>
<td>DTE</td>
<td>Data terminal equipment</td>
</tr>
<tr>
<td>DTMF</td>
<td>Dual-tone multi-frequency</td>
</tr>
<tr>
<td>EFR</td>
<td>Enhanced full-rate [GSM speech codec with improved quality]</td>
</tr>
<tr>
<td>ETSI</td>
<td>European Telecommunication Standards Institute</td>
</tr>
<tr>
<td>FEC</td>
<td>Forward error correction</td>
</tr>
<tr>
<td>FDD</td>
<td>Frequency division duplex</td>
</tr>
<tr>
<td>FDMA</td>
<td>Frequency division multiple access</td>
</tr>
<tr>
<td>FRAM</td>
<td>Ferroelectric random access memory</td>
</tr>
<tr>
<td>FFWD</td>
<td>Feed forward</td>
</tr>
<tr>
<td>FPLMTS</td>
<td>Future public land mobile telecommunications system</td>
</tr>
<tr>
<td>FTP</td>
<td>File transfer Protocol</td>
</tr>
<tr>
<td>GPRS</td>
<td>General packet radio service (packet radio service in GSM)</td>
</tr>
<tr>
<td>GSM</td>
<td>Global system for mobile communications</td>
</tr>
<tr>
<td>GSN</td>
<td>GPRS support node</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphic user interface</td>
</tr>
<tr>
<td>HDLC</td>
<td>High-level data link control (An ISO protocol standard)</td>
</tr>
<tr>
<td>HLR</td>
<td>Home location register</td>
</tr>
<tr>
<td>HPC</td>
<td>Handheld PC</td>
</tr>
<tr>
<td>HSCSD</td>
<td>High speed circuit switched data</td>
</tr>
</tbody>
</table>
HTTP  Hypertext Transfer Protocol
HW  Hardware
ICO  Intermediate circular orbit
IEC  International Electrotechnical Commission
IETF  Internet Engineering Task Force
IMTC  International Multimedia Teleconferencing Consortium
IN  Intelligent Network (A widely deployed network management concept originally introduced by Bellcore)
IP  Internet Protocol
ISDN  Integrated services digital network
ISO  International Organization for Standardization
ITC  Internet Telephony Interoperability Consortium
ITU-R  Radio Communications Sector of International Telecommunication Union
ITU-T  Telecommunication Standards Sector of International Telecommunication Union
IWF  Interworking function
IWU  Interworking unit
JDC  Japanese Digital Cellular
LAN  Local area network
LAPM  Link Access Protocol for Modems
LBR  Low bit-rate
LEC  Local exchange carrier
MAC  Media access control
MDC  Multimedia desk-top collaboration
MMCF  Multimedia Communications Forum
MMIC  Monolithic microwave integrated circuit
MMW  Multimedia Walkman
MNRU  Modulated Noise Reference Unit
MPEG  Moving Picture Experts Group
MSC  Mobile switching center
MSS  Mobile satellite services
OMC  Operations and maintenance center
OSI  Open systems interconnection
PBX  Private branch exchange
PC  Personal computer
PCS  Personal communications services
PDA  Personal digital assistant
PDC  Personal (or Pacific) Digital Cellular (alternately used acronym for JDC)
PPP  Point-to-Point Protocol
PHS  Personal Handy Phone System
POTS  Plain old telephone service
PSTN  Public switched telephone network
QCELP  Qualcomm code excited linear predictor
QCIF  Quarter CIF (176x144 luminance, 88x72 chrominance)
QFD  Quality function deployment
QoS  Quality of service
RD-LAP  Radio Data Link Access Procedure
RELP-LTP  Residual excited linear predictor - long term prediction
REW  Rewind
RF  Radio frequency
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTCP</td>
<td>Real-Time Transport Control Protocol</td>
</tr>
<tr>
<td>RTP</td>
<td>Real-Time Transport Protocol</td>
</tr>
<tr>
<td>SMTP</td>
<td>Simple Mail Transfer Protocol</td>
</tr>
<tr>
<td>SQCIF</td>
<td>Sub-Quarter Common Interchange Format (128 x 96 pels lum., 64 x 48 chrom.)</td>
</tr>
<tr>
<td>SQEG</td>
<td>Speech Quality Expert Group</td>
</tr>
<tr>
<td>SRP</td>
<td>Simple Retransmission Protocol</td>
</tr>
<tr>
<td>SS7</td>
<td>Signaling System 7 (The dominant ITU-T standardized digital signaling system)</td>
</tr>
<tr>
<td>SW</td>
<td>Software</td>
</tr>
<tr>
<td>TCP</td>
<td>Transmission Control Protocol</td>
</tr>
<tr>
<td>TDD</td>
<td>Time division duplex</td>
</tr>
<tr>
<td>TDMA</td>
<td>Time division multiple access</td>
</tr>
<tr>
<td>TMN</td>
<td>Telecommunication management network</td>
</tr>
<tr>
<td>TRAU</td>
<td>Transcoder unit</td>
</tr>
<tr>
<td>UB</td>
<td>Unlicensed band</td>
</tr>
<tr>
<td>UMTS</td>
<td>Universal mobile telecommunications system</td>
</tr>
<tr>
<td>UDP</td>
<td>User Datagram Protocol</td>
</tr>
<tr>
<td>UPT</td>
<td>Universal personal telecommunications</td>
</tr>
<tr>
<td>USR</td>
<td>US Robotics</td>
</tr>
<tr>
<td>VLR</td>
<td>Visiting location register</td>
</tr>
<tr>
<td>VOI</td>
<td>Voice over the Internet</td>
</tr>
<tr>
<td>VoIP</td>
<td>Voice-over-IP Forum (IMTC Experts Group on Internet telephony)</td>
</tr>
<tr>
<td>VSELP</td>
<td>Vector sum excited linear predictor</td>
</tr>
<tr>
<td>WAN</td>
<td>Wide area network</td>
</tr>
<tr>
<td>WAP</td>
<td>Wireless Application Protocol</td>
</tr>
</tbody>
</table>
REFERENCES:


[Bux 95] Buxton, W.: Integrating Periphery and Context: A New Model of Telematics


[Cox 96b] Cox, R., Kroon, P.: Low bit-rate speech coders for multimedia communication, IEEE Communications Magazine, Vol.34, No 12, December 1996, p. 34-41


[Emm 97] Emmett, A.: The wider, the better, America’s Network, February 1, 1997, pp. 32-4


[ETS96a] Draft GSM 03.34, High Speed Circuit Switched Data (HSCSD), Stage 2 Service Description, v. 0.4.0., February 1996

[ETS96b] Draft GSM 04.60, General Packet Radio Service (GPRS) , Overall Description of General Packet Radio Service (GPRS) Radio Interface (Um), v.0.5.0, April 1996.


[Fer 97] Ferranti, M.: FCC OKs wireless high-speed Sky Stations for Web access, Info-


[Fin 96] Finger S., et al.: Rapid Design and Manufacture of Wearable Computers, Commu-


[Gro 95] Groenen, W,: GSM and beyond Digital Cellular Mobile Technology on its Way to
Global Services, The GS; World Congress, Madrid, February 1995

[Har 96] Hara, Y.: Personal handy phone moves to data terminals, Electronic Engineering
Times, December 2, 1996,p. 26 (1 page)

July 1996, pp. 36-41

[Hee 95] Heer, D.N., Maher D.P.: The Heart of a New Information Appliance, IEEE Trans-

[Hoo 96] Hooper, G., Sicher, A.: Advanced TDMA digital AMPS mobile data and messaging
capabilities, Proc. of COM’96. First Annual Conference on Emerging Technologies
and Applications in Communications (Cat. 96TB100035), p. ix+205, p. 162-5. IEEE
Comput. Soc. Press; Los Alamitos, CA, USA

[How 88] Howard, J.: Changes in Consumer Behavior over the Product Life Cycle, Tuschner,
M.L.&Moore, W.L. editors: Readings in the Management of Innovation, Harper
Business, 1988, pp. 343-51

[HuR 96] Hu, R. et al.: Commercialization of PACS in the South-East Asia, ICCT'96. 1996
International Conference on Communication Technology Proceedings (Cat.


[ITU 93a] ITU-T, Terms and Definitions Related to the Quality of Telecommunication Services, ITU-T Recommendation E.800, 1993


[ITU 96b] ITU-T, Dual Rate Speech Coder for Multimedia Communications Transmitting at 5.3 kbps or 6.3 kbps, ITU-T Recommendation G.723.1, March 1996


[ITU 96g] ITU-T, Line Transmission of Non-Telephone Signals, Media Stream Packetization and Synchronization on Non-Guaranteed Quality of Service LANs, ITU-T Recommendation H.225.0, November 1996


[WuW96] Wu, W.: Great leap or long march: some policy issues of the development of the Internet in China