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 feed-back 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.

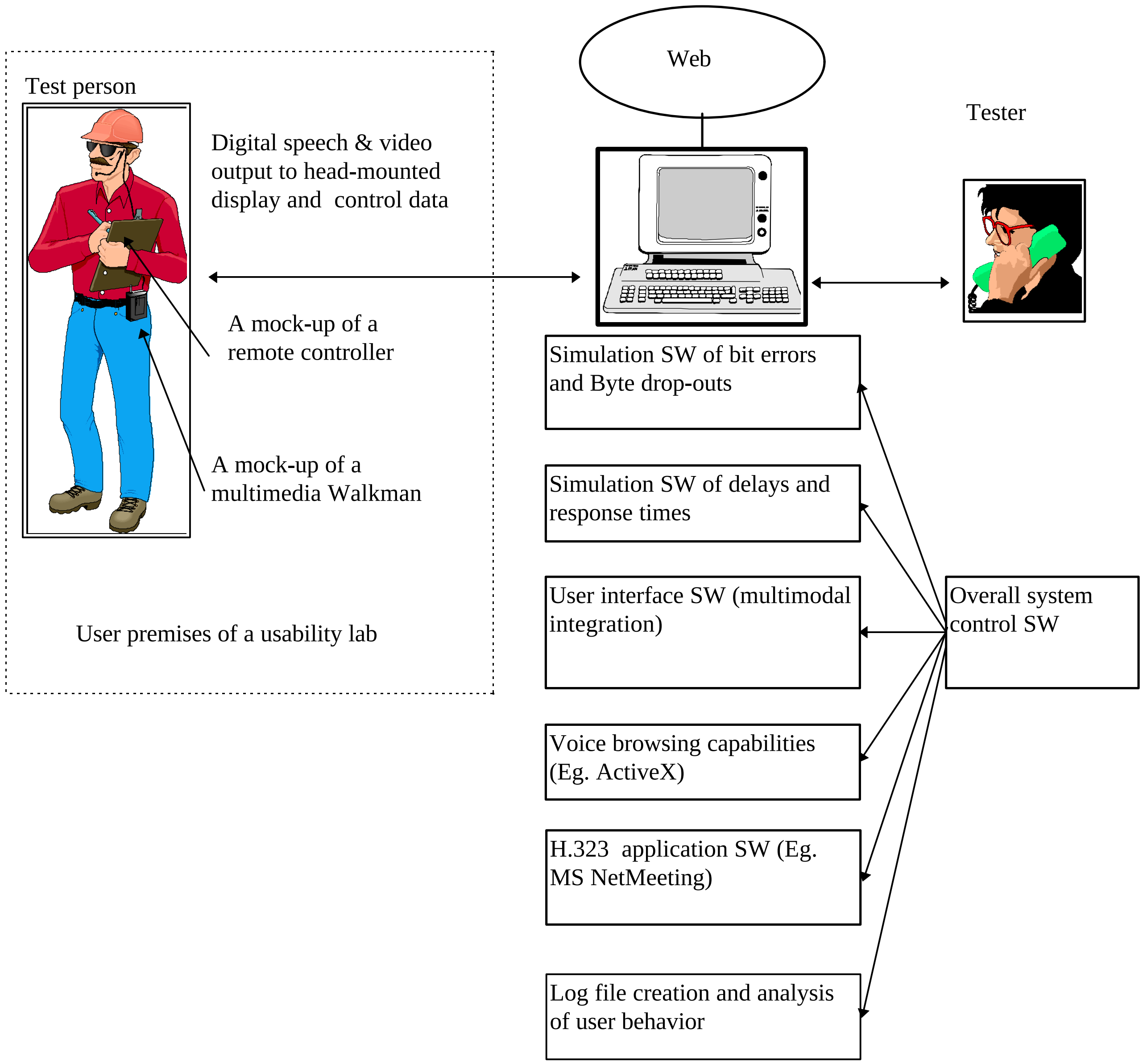


Figure 1 Suggested testbed architecture

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.

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 feed-back at least in limited scale.

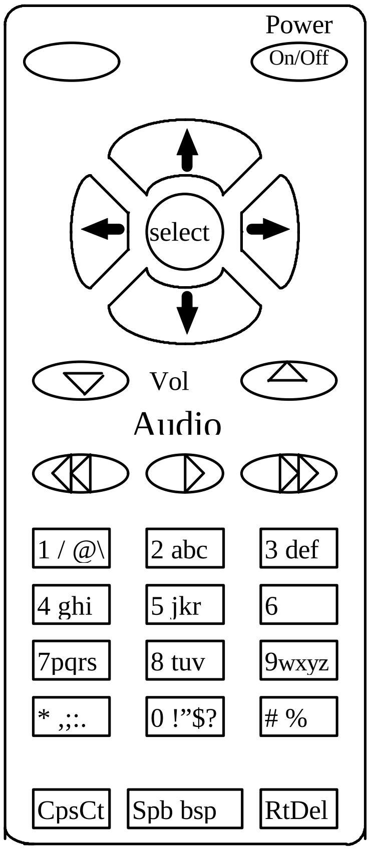


Figure 2 A model of a MMW remote controller with chording keys

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.

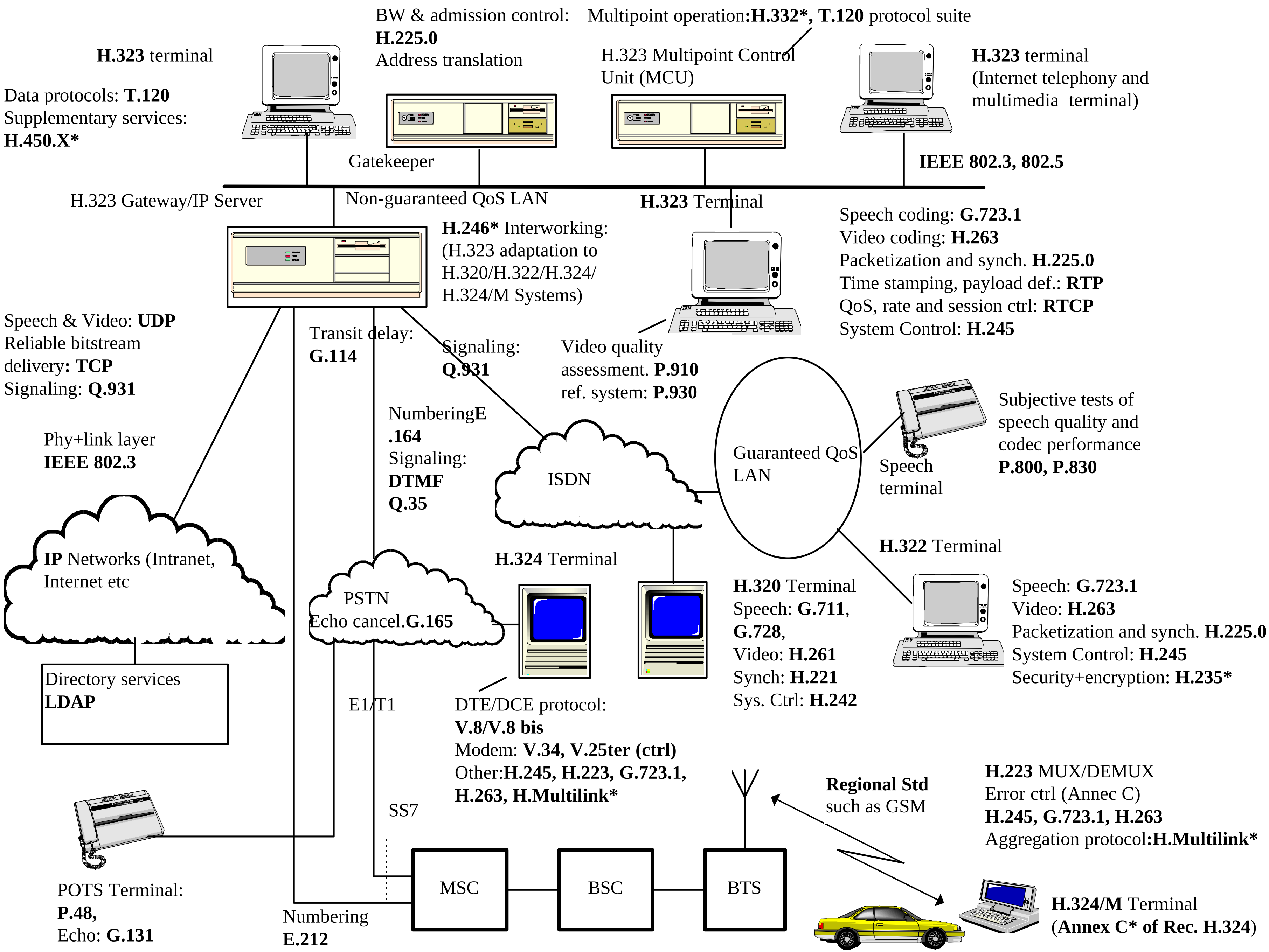
Evolution of wireless communications will be driven by the rapidly growing Chinese market, which is expected to become the largest one by year 2000. By its nature, this market is likely to leverage new digital technologies, which enable wireless local loops and low cost terminals, higher bandwidths, 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)



ABBREVIATIONS

ACR	Absolute category rating
A/D	Analog/digital
ADPCM	Adaptive differential pulse code modulation
ADSL	Asynchronous digital subscriber loop
AMPS	Advanced Mobile Phone System
ARQ	Automatic repeat (resend) request
ATM	Asynchronous transfer mode
AUC	Authentication center
BCH	Bose-Chaudhuri-Hocquenghem
BER	Bit error rate
BTS	Base transceiver station
BSC	Base station controller
CDMA	Code-division multiple access
CELP	Code excited linear predictor
CIF	Common interchange format (352x288 pels luminance, 176x144 chrominance)
CPU	Central processing unit
CRC	Cyclic redundancy check
CS	Circuit switched
CSMA/CD	Carrier sense multiple access/collision detection (IEEE 802.3 Ethernet protocol)
CSN	Circuit switched network
CTIA	Cellular Telecommunications Industry Association
DAVIC	Digital Audiovisual Council
DCR	Degradation Category Rating
DECT	Digital European cordless telecommunications
DRAM	Dynamic random access memory
DSD	Delay sensitive data
DSP	Digital signal processor
DCE	Data circuit-terminating equipment (a device that converts the DTE data into signals fit for the line, e.g. a modem)
DTE	Data terminal equipment
DTMF	Dual-tone multi-frequency
EFR	Enhanced full-rate [GSM speech codec with improved quality]
ETSI	European Telecommunication Standards Institute
FEC	Forward error correction
FDD	Frequency division duplex
FDMA	Frequency division multiple access
FRAM	Ferroelectric random access memory
FFWD	Feed forward
FPLMTS	Future public land mobile telecommunications system
FTP	File transfer Protocol
GPRS	General packet radio service (packet radio service in GSM)
GSM	Global system for mobile communications
GSN	GPRS support node
GUI	Graphic user interface
HDLC	High-level data link control (An ISO protocol standard)
HLR	Home location register
HPC	Handheld PC
HSCSD	High speed circuit switched data

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

RTCP	Real-Time Transport Control Protocol
RTP	Real-Time Transport Protocol
SMTP	Simple Mail Transfer Protocol
SQCIF	Sub-Quarter Common Interchange Format (128 x 96 pels lum., 64 x 48 chrom.)
SQEG	Speech Quality Expert Group
SRP	Simple Retransmission Protocol
SS7	Signaling System 7 (The dominant ITU-T standardized digital signaling system)
SW	Software
TCP	Transmission Control Protocol
TDD	Time division duplex
TDMA	Time division multiple access
TMN	Telecommunication management network
TRAU	Transcoder unit
UB	Unlicensed band
UMTS	Universal mobile telecommunications system
UDP	User Datagram Protocol
UPT	Universal personal telecommunications
USR	US Robotics
VLR	Visiting location register
VOI	Voice over the Internet
VoIP	Voice-over-IP Forum (IMTC Experts Group on Internet telephony)
VSELP	Vector sum excited linear predictor
WAN	Wide area network
WAP	Wireless Application Protocol

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