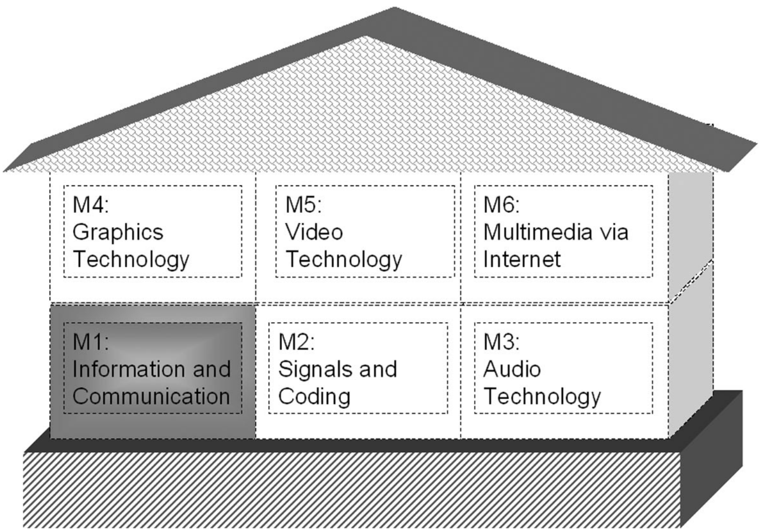
Module 1: Information and Communication

„The word information, in this theory, is used in a special sense that must not be confused with its ordinary usage. In particular, information must not be confused with meaning.“

Claude E. Shannon on page 8 in his „Mathematical Theory of Communication"

Learning objectives

Multimedia Systems are **Information Systems** (IS) in which *all* kinds of auditory and visual information are offered. In order to understand various types of information and information processing, a thorough understanding of the basic principles involved is necessary. This knowledge is presented in the following **Information and Communication Theory**.



Information and Communication is not only important in computer science, but is also of central importance to the existence of (civilised) life in our world, only consider the transmission of hereditary information (genetic blueprints) or the inter-communication of living beings.

In each case the information transmitted, and the systems used for these interchanges, become increasingly complicated and abstract.

Fig. 1.1 Computer Science and Information Technology (IT) are the basis of the modern information society

With the entrance into the **digital world** of information processing with multimedia – distributable over world-wide networks – a completely *new media* is made available. The society in which we live is becoming increasingly more dependant on **information.** Due to satellite technology, optical fibre technology and millions of cross-linked computers worldwide, the technical possibilities of information and communication (IaC) have increased an inconceivable amount. All these elements set the foundation for a world wide **Society of Knowledge.**

Computer Science and Information Technology are continually breaking down currently putative boundaries. With data transfer rates exceeding 10 Gigabits per second, the post-modern information society becomes reality. The Internet penetrates our everyday life with a nearly infinite abundance of information. Information obtains an increasingly important position.

In the industry 75% of employees no longer work with material, but with information. Up to 50% of product costs and more than 50% of indirect costs are information expenditure.

Signals in the next Module; Knowledge in Volume 2

However, just at a time in which (almost) everyone has the possibility of accessing an practically unlimited amount of information, it is necessary to provide a permanent and basic knowledge of signals, data, information, knowledge and communication.

1 Information

The Human as an Information Processing System

People can be viewed as information processing systems (IPS). Every IPS consists of

- Input channels (Receivers and sensors),
- Processing elements (Processors and memories) as well as
- Output channels (Effectors and actuators).

People are, however, more than mere data processing systems: They are information interpreters, ambiguity solvers and problem analysts.

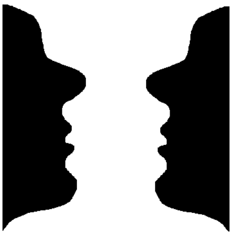


Fig. 1.2 The „Rubin cup", so named after the Danish psychologist Edgar Rubin, it illustrates that the figures in the picture can only be recognised individually - not both simultaneously

For example, what does the „shadow figure" represent in the picture 1.2: Two faces or a vase? Which of the figures was recognised first?

The **interpretation** of information – in the example of *visual information* - is always dependent on the person who absorbs and evaluates this information subjectively.

Multimedia-systems are **interactive information systems.** The fundamentals of **information processing** are valid.

However, before occupying ourselves with information processing some central questions must be answered: What are signals? What is data? What actually is meant by information? What is knowledge?

The fundamentals of „Signals" are dealt with in Module 2 of this volume and the topic „Knowledge" in Module 2 of Volume 2 „Multimedia Basics: Learning".

1.1 Terms and Definitions

The use of such terms as *signal, data, information* and *knowledge* are in everyday use. We „send signals", „pass on data", „obtain information" and „acquire knowledge". However, in connection with Information Systems we need to have these terms clearly defined.

1.1.1 Signals

Signals as physical information carriers

According to the DIN i44 300 standard (DIN = Deutsche Industrie Norm, German Industrial Standard), Signals represent the **physical carriers** for data which act as carriers of information in turn. As shown in module 2, we distinguish between two essentially different kinds of signals:

- **analog signals,** consisting of **continuous functions,** and
- **digital signals,** consisting of **discrete (single) characters.**

Signals are *functions* or *characters* which, via auditory, visual or other physical-technical means, can be used to transmit data.

Example: In a multimedia-production the speakers' words are the information intended for the listeners. A microphone changes the sound signals into electric signals. These are digitised and stored, for example on CD-ROM. With a digital analog converter, amplifier and loudspeaker the information „Speech" is reconstructed (see module 3).

1.1.2 Data

Data are facts. To quote the DIN 44 300 again – „This term represents signs or continuous functions, on the basis of known or assumed arrangements, for the purpose of transmitting information".

In computer science data are coded information stored in computer systems. The information can be represented by character strings **(digital data)** or continuous mathematical functions **(analog data)** and processed by machines.

Data are coded Information

Since the book series „Basics Multimedia" is not limited to technical basics, we must further classify data as follows:

Quantitative data are information to which defined **numerical values** can be ascribed (for example 1, 2, 3 ...).

Qualitative data are information in the form of **non-numeric attributes** which can be divided into different classes (for example „feminine", „masculine" or „neuter").

Qualitative data can be partially converted (coded) into quantitative data (for example „feminine = 1", „masculine = 2").

A quick way to differentiate between data, information, and knowledge is by utilizing a practical day-to-day application. Consider the word „Multimedia", which consists of the alphanumeric characters m-u-l-t-i-m-e-d-i-a. Each alphanumeric character can be represented by ASCII code (see Module 2). This ASCII code is stored in the computer's memory and is called data. This data (ASCII a = 01100001) is fairly meaningless by itself; only the forming of words (and sentences) is the beginning of having information.

1.1.3 Information

The term information (lat. informatio = „idea“, „instruction“, „training“) is employed in the various disciplines of science and technology differently:

In nature, for example, information is defined as „every difference that makes a difference“ (BATESON), or to be more specific: „Information is the alteration process, that leads to an increase in knowledge (SCHUCAN)“ or a further specification: „Information is a usable answer to a given question“ (ZEHNDER).

In telecommunication the information theory as defined by SHANNON & WEAVER is used (see chapter 2).

Basically information is only statements or news which bring something new. Therefore information must have an information content – a meaning (Chapter 2.2). Simply expressed, frequent monotonous events do not offer anything new and cannot be classed as information in this sense.

The „news content“ not the „weight of content“ defines information

New, surprising or *rare* occurrences are (information-technical) informative. The information lies in the signals *change*.

Experiment: A voice producing a uniformly monotonous and repetitive tone, for example the sound „aaaaaa......“ over a longer period of time, then modulated by vocal information, for example by reading this text out loud.

Information is a sequence of physical signals, fluctuating (changing) in time or space and consisting of a material **carrier** and the **information content.**

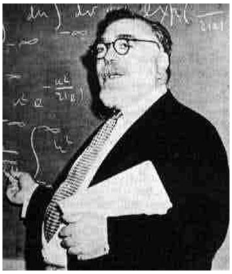


Fig. 1.3 Norbert Wiener established Information as the third basic component – next to matter and Energy [W7]

NORBERT WIENER„ founder of cybernetics (Theory of communication and regulation systems in living organisms, social organizations and technical systems), even establishes information as the **third basic component** in his system environment.

KUHLEN (1999) gives an interesting definition: „Information is a subset of knowledge which is necessary in actual action situations and is not available before the information is processed. Accordingly, information is significantly dependent on the context factors of the users and the utilization“.

The dependence on the **context** becomes particularly obvious in the theory and practice of communication (see chapter 3).

1.1.4 Knowledge

Knowledge is applied Information

Knowledge (German: Wissen; Latin: scientia; Greek: episteme) is the result – the aim of (human) information processing.

Knowledge and thinking are inseparably in connection to the human brain: Knowledge is (in the human memory) organized, available and applicable information.

Fig. 1.4 Heinz Zemanek (born 1920), the computer pioneer, during his address on his eightieth birthday [W6]

According to HEINZ ZEMANEK, stored information certainly appertains to knowledge, but this first becomes knowledge when the context, supplied by the unique combination of our sense organs – and exactly this is achieved by multimedia technology – is processed by human intelligence.

Neither a telephone directory nor a database are knowledge – however, with knowledge one can extract considerable sense from both (Heinz Zemanek).

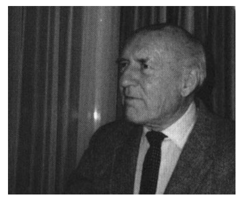


Fig. 1.5 Heinz von Foerster (born in 1911 in Vienna) was one of the „architects“ of cybernetics, together with Warren McCulloch, Norbert Wiener, John von Neumann and others [W10]

HEINZ VON FOERSTER.(1998) asserts – conform with the Constructivism (see Volume 2), – that knowledge *can not be imparted:* It can not be treated as an object, a thing that one can transfer from A to B – like sugar or coffee – to accord a specific effect in an organism.

Knowledge is „forward looking“ and probabilistic: that means that the value of any knowledge is only high if the predictions are correct with reference to the (relevant) transmission channel.

This is in contrast to information, which is possibilistic, since the most improbable signs contain the most information content (see chapter 2.1).

More about that in the module „Knowledge“ in the volume 2.

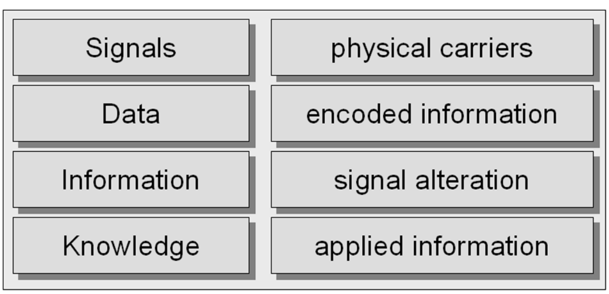


Fig. 1.6 Summary of the terms used

2 Information Theory

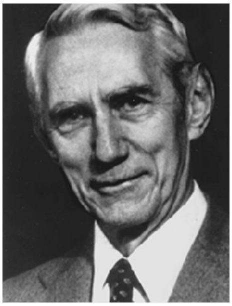


Fig. 1.7 Claude E. shannon (born 1918 in Michigan) established his information theory in 1948. He died on 24th February 2001 [W2]

The information theory arose from the work of CLAUDE ELWOOD SHANNON and represents a fundamental **basis for computer science.**

The information theory is used for mathematical description of information systems and is closely influenced by telecommunications.

With the aid of a homogeneous theory, it is possible to compare different methods of information transmission and to optimize the individual components of a transmission system.

An information system is subject to the laws of telecommunications and can be represented by the communication model from SHANNON & WEAVER as shown in Fig. 1.8.

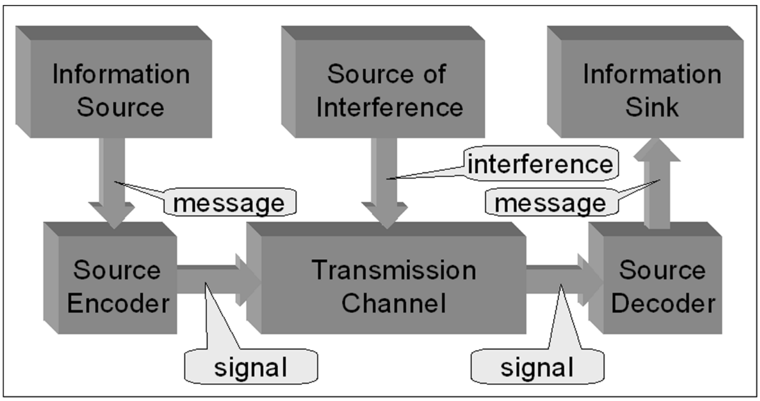


Fig. 1.8 The communication model from Shannon & Weaver describes the flow of information between sender and receiver

The information theory is also an important component of psychophysics (see module 3) and is necessary for the psychological analysis of communication (see chapter 3).

2.1 Information content

In the information theory according to SHANNON & WEAVER the information content of a message is defined from a purely mathematical viewpoint and the importance of the information is completely ignored.

With reference to our definition of the term information, based on telecommunications engineering usage (Chapter 1.1.3), the information content of a message must possess the following characteristics:

- The information content I_x of an information x must be greater the smaller the probability p_x of the occurrence (the bigger the „surprise value").
- An information with the probability $p_x = 1$ must have the information content $I_x = 0$.
- The information content of independent messages should be additive.

However, when speaking of information content, it must be distinguished between first of all, whether discrete characters with the same occurrence probability or discrete characters with different occurrence probability are employed.

2.1.1 Information content of discrete characters with equal probability of occurrence

The information content I results from the entire character set s. If, for example, we take the whole numbers from 0 to 15 we get a character set of $s = 16$. Putting these numbers into binary we get:

$15 = 1 \cdot 2^3 + 1 \cdot 2^2 + 1 \cdot 2^1 + 1 \cdot 2^0 = 1111$

$14 = 1 \cdot 2^3 + 1 \cdot 2^2 + 1 \cdot 2^1 + 0 \cdot 2^0 = 1110$

through to

$0 = 0 \cdot 2^3 + 0 \cdot 2^2 + 0 \cdot 2^1 + 0 \cdot 2^0 = 0000$

lb = binary logarithm to the base of 2, also referred to as ld (logarithm dualis) i.e. $\log_2$

In order to represent our character set of $s = 16$ in digital form, we therefore need a four-digit (4 bit) binary number, thus 4 = lb (16). Therefore it follows that the information content:

$$I = lb(s)$$

I Information content in bit
s Quantity of different characters (number set)
lb binary logarithm (= base 2)

The use of the logarithm to the base 2 is only a question of scale. The basis 2 was chosen because, for the simplest case of a symmetrical binary information with $p_x = 0{,}5$ the information content of a character becomes $I_x = 1$ bit.

The unit for information capacity is the **bit.**

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binary digit – the unit of information

The term **bit** („binary digit") used to have two different meanings:

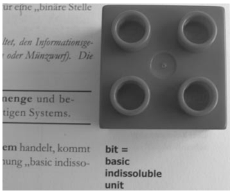

Fig. 1.9 A binary cell is, so to speak, the „smallest brick“

- A binary digit, 0 or 1. This is usually displayed as an integer. These „bits“ are the individual and basic pieces of data in computers.
- A measure of uncertainty, H, or information R. This can be any real number because it is an average. This is the measure that SHANNON originally used to discuss communication systems and is known properly as „the Shannon“.

In principle something contains the information content of one bit when it includes two possibilities (e.g.: A light switch on/off or the toss of a coin heads/tails). The binary elements„0“ and „1“ are used as the basic components.

In digital Multimedia a bit is **the smallest binary information** capacity and describes the logical state of a two-value system.

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bit = basic indissoluble unit

The fact that it is a matter of a minimum system is expressed by the term „basic indissoluble unit“, initially introduced by SHANNON.

An different example from „informational routine“: How large is the information content of a seven-digit safe code (1234567)?

s = 10 (for the digits of 0 ... 9) from this:
I = 7 lb(10) bit = 7 x 3,32 bit = 23,26 bit

To the declaration: lb 10 = ^{2}lg10

$$2^x = 10 \Rightarrow x\log(2) = \log(10)$$

$$x = \frac{\log(10)}{\log(2)} = \frac{1}{0,30103} = 3,3219281$$

2.1.2 Information content of discrete characters with unequal occurrence probability

In our previous examples, it is assumed that the probability p_x of occurrence is equal for all characters (numbers).

The p_x of a character given s possible characters is then

$$p_x = \frac{1}{s}$$

Laplace Probability

whereby this expression – known from the Probability Theory – represents the number of favourable results divided by the number of possible results.

Therefore the following is valid for the information content:

$$I_x = lb(s) = lb\left(\frac{1}{p_x}\right)$$

If every character has an individual probability p_{xi} the equation reads:

$$I_{xi} = lb\left(\frac{1}{p_{xi}}\right)$$

These facts can be graphically illustrated as follows:

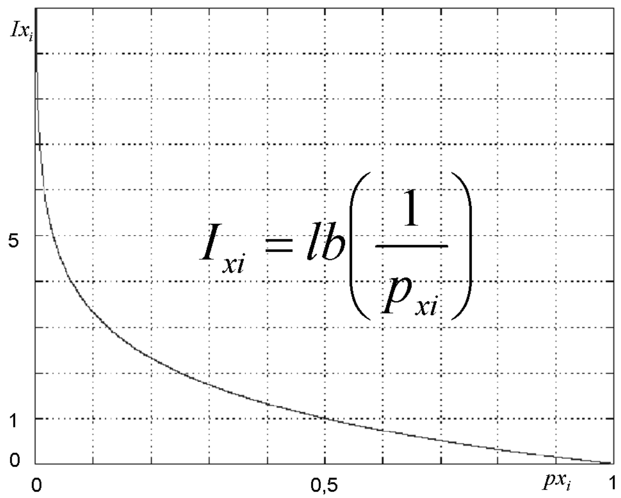

Fig. 1.10 Information content (with varying character probability)

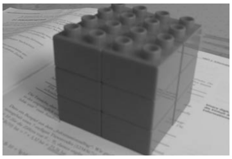

Fig. 1.11 Absolutely homogenous order of 12 „Lego-Bricks“

> The information content should be independent of the code form and depend exclusively on the probability with which the receiver expects the information.

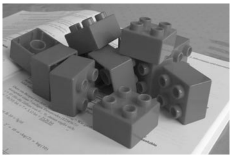

Fig. 1.12 Absolutely disorder

Messages that are expected with high probability, have a low information content, whereas those expected with small probability have a correspondingly high information content. Examples with Lego bricks (Figures 1.11 until 1.13) help to clarify these facts and to illustrate the following question: Which order contains the maximal informational content?

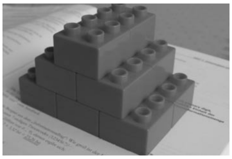

Fig. 1.13 A defined order with a distinct „construction plan“

Figure 1.11 shows a completely uniform arrangement of 12 Lego bricks: The information content is small. In picture 1.12 the 12 Lego bricks are in absolute disorder: The occurrence of a specific order is accidental and extremely improbable and is therefore the arrangement with the highest information content. Generally the „average“ is the rule: A defined arrangement, for example the „house“ in picture 1.13.

2.2 Entropy

Entropy is the degree of disorder within a system

The term entropy is borrowed from Thermodynamics (Calorific Theory), where entropy is a measure of statistical disorder (uncertainty) in a thermodynamic system.

For the **average information content** of a message, we can take the arithmetic mean value as the sum of all p_{xi} multiplied individual information content I_i:

A higher Entropy value H means a greater uncertainty about the meaning of the message

$$H = \overline{I_x} = \sum_{i=1}^{s} p_{xi} lb\left(\frac{1}{p_{xi}}\right)$$

H – in the sense of entropy in telecommunications engineering – designates the average information content of a message.

2.3 Redundancy

The **maximum** entropy in telecommunications engineering is also referred to as **decision content** H_0. This is given when the individual information elements are equally distributed and therefore statistically independent.

A deviation from the uniform distribution causes a decrease in the average information content of a message. This decrease is referred to as **redundancy** R.

Assertion:

$$R = H_0 - H$$

and

$$r = \frac{H_0 - H}{H_0}$$

R redundancy
H_0 decision content (mean entropy)
r relative redundancy

Example: Assuming the occurrence probability of all alphabetic characters in a language ($s = 26$) to be equal ($p_x = 1/26$) and also assuming the letters to be independent of each other, the information content of one letter (and also the mean value) would be $H_0 = I_x = \text{lb}(26) = 4{,}7$ bit.

However, in actual fact the letter „e“ occurs far more frequently in the English language than the letter „z“. Taking this frequency in account, the true entropy is H = 4,1 bit/Symbol.

It must be also be taken into consideration that certain combinations of letters occur more frequently than others. For example, the probability is higher that the letter "a" will be followed by "n" rather the "o". Taking these conditional probabilities into consideration one arrives at: H = 3 bit/ Symbol.

If still the dependencies of the conditional probability on all longer alphabetic orders and also the impossibility of the occurrence of specific alphabetic orders are considered besides, a value of H = shows to 1,3 bit/ Symbol.

With that, following values can be applied for the English language:

Information-theoretical numbers of the English language

H = 1,3 bit/Symbol
R = 3,4 bit/Symbol
r = 0,5

Compare: 73 % of the German language are redundant

50 % of the English language are redundant („superfluous“), and 50% are information supporting.

This redundancy of the language is **not** unwanted. Although these indeed the actual information increases and slow down the flow of information, an error recognition and error correction with faulty news are allowed by that.

Information without redundancy is absolutely worthless, because it has no reliability

2.4 Flow of Information

The data transfer rate of any information becomes increasingly important. This rate is called information flow and defined as follows:

$$F = \frac{H}{t_m}$$

whereby:

$$t_m = \sum p_x t_x$$

F Flow of Information in bit/s
t_m average period for the transfer of one character in s/Symbol

2.5 Channel capacity

For distributed information systems (for example: net based multimedia systems) it is especially important to know the upper limit of capacity of the transmission channels employed.

With the term "Channel", we mean an arbitrary path which the information can take from the sender to the receiver.

The channel capacity is the maximum information flow which can be transmitted via a communication channel without error.

The flow of information is dependent on the information source and on the transmission channel.

The channel capacity is an important quality criterion for Information Systems

Whereas the channel capacity is independent of the information source capabilities and depends only on the type of transmission channel.

It is a question of the absolute upper limit of performance; it can be computed as follows:

$$C = F_{max} = \left(\frac{H}{t_m}\right)_{max}$$

C channel capacity in bit/s

For a transmission channel disturbed by interference i.e. noise (interference is also, although in this case unwanted, information) with a bandwidth B the following formula is valid:

$$C = B\,lb\left(1 + \frac{P_S}{P_N}\right)$$

B Bandwidth in Hz (hertz, 1/s, see glossary)
P_S Signal Power Output in W (watts, S = Signal)
P_N Noise Power Output in W (N = Noise)

In actual usage the information flow in a transmission channel remains far below the channel capacity. Taking into consideration:

$$lb(x) = \frac{lg(x)}{lg(2)}$$

we proceed to a base 10 Logarithm and obtain with lg(2)~0,3::

$$C \approx \frac{B}{3} 10 lg\left(1 + \frac{P_S}{P_N}\right)$$

whereby

$$10 lg\left(1 + \frac{P_S}{P_N}\right) = \rho$$

This ρ represents the signal-interference ratio (in dB), and is generally known as the signal-to-noise ratio **SNR** (in dB).

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dB = Dezi-Bel, see Module 3, chapter 2.3.2

In most cases the signal is very much higher than the interference, then applies:

$$P_S \gg P_N$$

$$\rho \approx 10 lg\left(\frac{P_S}{P_N}\right)$$

The channel capacities of transmission channels are very different:

Transmission channel	*B*	*r*	*C*
Telegraphy	25 Hz	15 dB	75 bit/s
Analogue Telephone	3,1 kHz	40 dB	50 kbit/s
FM-Radio	15 kHz	60 dB	300 kbit/s
Television	5 MHz	45 dB	75 Mbit/s
ISDN	64 kHz	60 dB	64 kbit/s
Broadband (ATM)	10 MHz	45 dB	155 Mbit/s
Comparison: Eye	285 THz	-	10 Mbit/s

Fig. 1.14 Channel capacities of some typical channels
B = Bandwidth
r = Signal-to-Noise ratio
C = Channel capacity

The problematic of Bandwidth will be discussed in Module 6 „Multimedia via Internet"

A rising demand for channel capacity, with a continuously increasing rate of data to user interfaces, has arisen from the increase in the number of Internet-users and the growing supply in the multimedia-field. Nowadays, data at rates in the Gbit/s and Tbit/s range are only transmitted over wide areas via optical transmission channels (glass fibre). The glass fibre comes closer to the user (FTTH-Fibre To The Home).

FTTH = „fiber to the home"

2.6 Information Cuboid

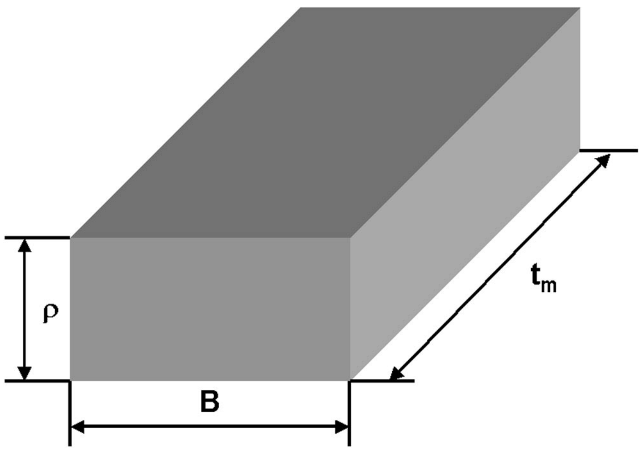
The portable information capacity (the "information volume") can be vividly pictured as cuboids and are occasionally also referred to as "information cuboids" (Figure 1.15).

The lengths of the ashlar's sides (the parameters) depend on the

- available bandwidth *B*,
- noise margin ρ and
- available transmission time t_m.

An information cuboid can be represented graphically:

Fig. 1.15 Information cuboid, with Bandwidth *B*, Signal-to-Noise ratio ρ and transmission time slot t_m



The correct dimensioning of these three parameters is necessary for an optimal information transfer.

Example: For an Internet-Service-Provider (ISP) both bandwidth and transmission time are important values for measuring the accessibility (Channel capacity) of his customers to the external net (Internet).

According to SHANNON the volume of the information ashlar is equal to the theoretical limit of the maximum portable information capacity.

3 Communication

The development of a Mathematical Theory of Communication by SHANNON & WEAVER – following on the preparatory work of NYQUIST, HARTLEY and KÜPFMÜLLER – covers the subject of discrete signals in detail.

The concept of information according to SHANNON & WEAVER only concentrates on technical-mathematical communication. The **meaning** of the signals is totally ignored.

Meaning

Very rapidly, psychologists, pedagogues (educationalists), sociologists and especially cognitions-scientists were animated to apply this theory to (human) communication processes in a broader sense.

If we want to understand the Human-Computer Communication – we first have to understand the Human-Human communication

Communication (from lat. communicatio = "Communication, conversation") is generally the understanding (exchange of information) between people, people and machines or between machines.

Communication can be used for a one-sided or mutual exchange of information. If this information occurs in the form of text, speech and music, pictures and videos, it is referred to as **telecommunication.** Enhance this telecommunication extended by the possibility of **interaction** and „true“ **multi-media communication** is achieved

Telecommunication

Multimedia-Communication

If systems implement international standards (OSI) enabling them to communicate with other systems which support equivalent standards, they are referred to as **Open Communication** Systems.

OSI
Open Systems Interconnection – a Working Group of ISO

Communication is every exchange of information with definable information content (Message).

Communication is a **process** which includes the following elements:

- Sender,
- Information (the "communication") and
- Receiver.

The communication is expressed through symbols in a medium and transmitted by a channel. A successful communication is possible, when the symbols employed are accessible to both participants.

3.1 Semiotics as a Foundation

Fig. 1.16 A Communication becomes first possible, if sender and receiver are in the possession of a suitable character set

The evolution and, in particular, the spread of unambiguous **symbols** were an necessary postulate for the transfer of information, as for example in sign language, speech, writing, light signals etc.

Mankind's earliest and to date most important "Symbol System" is the spoken word (language). Pictures were the early pre-forms of writing. People first expressed their ideas with cave drawings. The first figure systems and later the oldest known writing systems in Mesopotamien, Egypt and China were developed from these drawings (Pictograms).

Semiotics is defined as the **Science of Signs.** It was recognised as a separate science at the beginning of the 20th. century due to the works of CHARLES SANDERS PIERCE (1839–1914) and FERDINAND DE SAUSSURE (1857–1913).

According to PEIRCE (in 1931) the basis of the communication process is a **linguistically** and **culturally** determined (established), but *still evolving* **interpretation of signs.**

Fig. 1.17 Charles Morris (1903–1979) divided the die Semiotics in Syntactic, Semantic and Pragmatic

> Semiotics is the basis of the exploration of subject and operation modes of communication processes. Semiotics is subdivided into Syntactics, Semantics and Pragmatics.

Building on the works of PEIRCE, CHARLES WILLIAM MORRIS developed a sign theory (Semiotics), with a social-psychological emphasis, on the background of behaviourism (See volume 2).

He divides semiotics into three disciplines: Syntactics, Semantics and Pragmatics.

Syntactics (pertaining to syntax) describes and analyses the inner formal relationships between the different symbols of a sign system and attempts to find reasonable and permissible character strings.

Semantics examines the relationships between symbols and objects, e.g. the subjects to which the symbols relate. Every symbol has an **meaning** and *"designates"* an object. In this case the "object" need not necessarily be physical, the term can also be used to refer especially to terms, thoughts, ideas etc.

Pragmatics examines the relationships between symbols and those using them. A symbol is employed in order to produce an **effect;** pragmatics deals with this application.

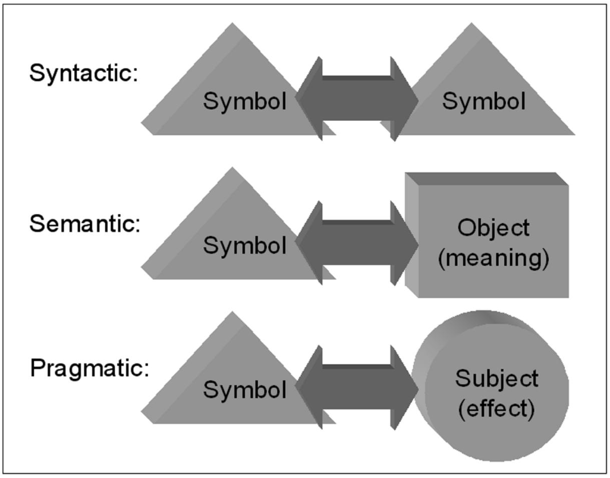


Fig. 1.18 Semiotics is subdivided into Syntactics, Semantics and Pragmatics

3.2 Processes of Communication

3.2.1 Three levels of communication

All communication processes between sender and receiver work on three layers. The lowest layer (the foundation or base) describes the purely syntactic layer: the physical transmission of signals. The middle layer compromises the meaning of the signals, while the effect is incorporated into the third level:

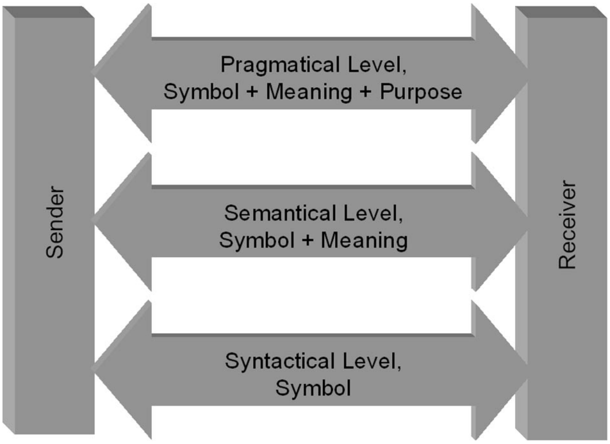


Fig. 1.19 The three levels of communication between sender and receiver

3.2.2 Axioms of Communications

The following five theses form the core of WATZLAWICK'S Theory:

Fig. 1.20 The five pragmatic axioms of Watzlawick

1. Axiom:
You cannot not communicate

2. Axiom: Every interaction has both a content and a relationship dimension

3. Axiom: Every interaction is defined by the way it is punctuated

4. Axiom: Messages are digital and analogic (verbal and nonverbal)

5. Axiom: Communication exchanges are either symmetrical or complementary

Fig. 1.21 Watzlawick (born. 27. 7. 1921 in Villach, Austria), since 1960 Member of the Mental Research Institute (Palo Alto), since 1967 Lecturer at Stanford University [W4]

- One cannot "actively not communicate": Anyone attempting to inform a conversational partner of their intention not to communicate – has already communicated.
- Communication has a textual or material aspect (content) and a relationship aspect: Not only the content of a statement but also the tone, expression and the manner of delivery, – whether due to positive or negative emotions – is decisive in the interpretation made by the addressee.
- In particular if the "channels" of communication disagree (if for example a friendly content is sent in an unfriendly manner), this can lead to interpretation problems for the addressee or to a so-called "connection gap" ("drop" or "slump").
- The (different) punctuation of event sequences defines the nature of the relationship: One's behaviour is mutually defined as a reaction to another's behaviour, which can lead to pathological cycles with increasing alienation.
- We differentiate between digital and analogous communication. WATZLAWICK defines digital thus: The meaning of linguistic signs (terms, sentences) is independent of the content they refer to. Whereas analog communications bear a direct relationship to their content. (This is valid for for body language, mimicry, gesticulation: for example a smile usually expresses positive state of emotion).
- The relationship between people communicating is symmetrical or complementary. An upright social relationship exists between students and their professors (complementary communication). Between peers, the communication is symmetrical, for instance among friends or spouses in a modern society.

Every relationship has individual advantages and disadvantages for the communication

Digital communication has a complex, versatile logical syntax with, however, insufficient semantic for the field of relationships. **Analogous communication** does have this potential but lacks the logical syntax necessary for unambiguous communication.

WATZLAWICK advocates a system theory based on the assumption that every communication represents an integrated continuity.

A linear sender and receiver pattern cannot deal with these requirements:

Also, the communicants exist within an interacting environment, within which "Feedback" is produced which can, if negative, lead to pathological cycles of communication.

WATZLAWICK also advocates so-called "Radical Constructivism“. This is an epistemology (Theory of Knowledge) based on the premise that an objective reality does not exist: Everything we accept as "reality" is actually the result of our own subjective perceptions.

The understanding of other people is a rather unlikely case, it is much more probable that they do not understand if itself everyone means to have understood the other one

The practical starting point for WATZLAWICK'S *communication theory was the faulty communication of mentally ill people, schizophrenic patients and their families.* WATZLAWICK *applied the paradoxes of linguistic communication forms he had discovered to normal communication and came to the surprising result that such communication paradoxes also occur in the everyday life of very normal people – and were the cause of misunderstanding.*

According to WATZLAWICK everyone lives in his own, self-constructed, inner world, which he accepts as reality and assumes that everyone else also conceives the same reality.

If the communicant's differing awareness of reality (of which they are unaware) lead to a communication conflict, they either become confused or assume that the behaviour of the other is at fault.

This conflict situation can not be solved by the people themselves because they are too rooted in their own interpretation of reality.

WATZLAWICK intentionally exaggerates of course. Without knowing his precise background information and correlations, we must deal with his theories cautiously. Nevertheless, it makes particular sense to be aware of his theories and their relevance to multimedia.

3.3 Types of Communication

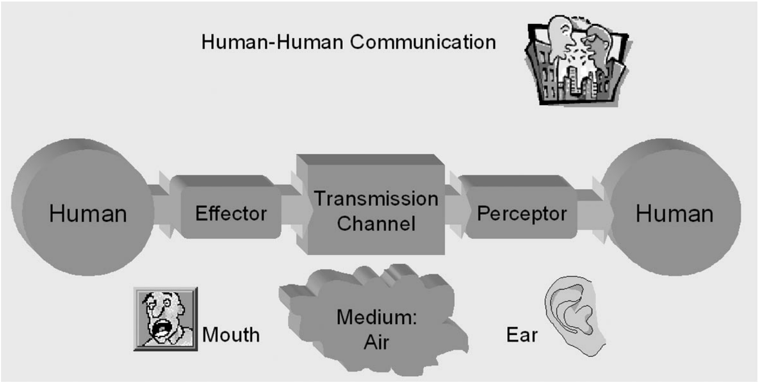
It is possible to differentiate between four types of communication:

- Human-to-human communication, with the special case of
- Human-machine-human communication,
- Human-machine communication and
- Machine-machine communication.

3.3.1 Human–Human Communication

Human-to-human or Person-to-person communication is the type of communication by which people communicate directly with each other. This can be, for instance, the direct exchange of information, a discussion of specific ideas or negotiations in a conflict situation.

Fig. 1.22 The structure of the human-to-human communication



inter-personal = between humans

Human-to-human communication *(Person-to-person)* is known as **inter-personal communication** and represents an important and basic **social communication.**

Inter-personal communication is effected through two different (mutually comparable) kinds of symbol systems:

Proxemics, Example: In Europe mourning people wear black clothes during a funeral – in Japan white clothes

- **verbal-linguistic** (vocal), for example language or sounds (laughter, snoring ...) and
- **nonverbal-non linguistic** (nonvocal), for example signals (flashlight signals), signs (flags), symbols and pictures (icons), (gestures, mimicry and gesticulation (kinesics), communicative dimension of the human proximity behaviour (proxemics) and culturally dependant behaviour, for example mourning (grief).

Communication between humans is effected directly through interactive gesticulation, mimicry, sounds and language. Both sender and receiver must draw from the same set of symbols – to understand each other.

If we switch a machine, such as a telephone, into the communication we obtain a human-machine-human communication.

3.3.2 Human-Machine-Human-Communication

This kind of communication is called **indirect communication.** The essential difference to person-to-person communication is that the information is carried, via an transmission channel, through the intervening machine from the sender to the receiver.

Computers established themselves in Human-machine-human Communication by virtue of their *universal adaptability*.

This kind of communication is widely distributed on the Internet, for example in eMail, IRC (Internet Relay Chat), Internet-telephony (IP-telephony) or tele-conferences.

eMail, Chat, IP-Telephony, Tele conference

Classical examples of this type of communication, apart from Internet, are for instance telephone conversations, fax (facsimile telegraphy) and of course the evergreen "letter" when produced either on a computer or a typewriter. Very few letters are still written by hand.

The medium, over which the communication is transmitted, is of far less importance than the person or persons for whom the communication is intended.

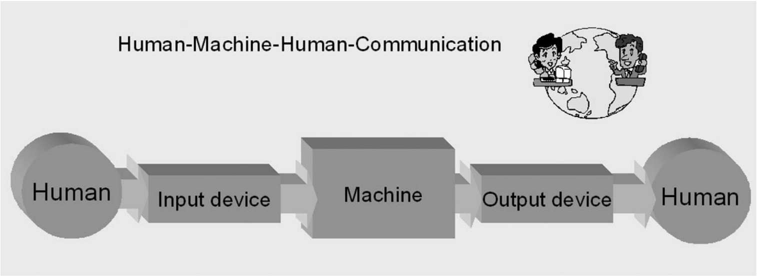


Fig. 1.23 The information from human to human passes through the "intermediator" machines

3.3.3 Human–Machine Communication

Human-machine Communication is the communication between a human and a machine (Computer). This kind of communication is particularly widespread in Internet and Intranet.

HCI Human-Computer Interaction is an field of increasing importance and will be covered in volume three of „Basics Multimedia"

In computer science (IT/Informatics) the term HCI (Human–Computer Interaction) is generally used. HCI concentrates on the:

- organization,
- implementation and
- evaluation

of interactive information systems (IIS), and is supported by **Software Ergonomics** and **Usability.**

Typical examples for this are data bank queries (query/answer) or ITS (Intelligent Tutoring Systems). The user appropriately formulates the question, for example by entering search keys (strings of characters or numerals) into an input mask or screen, and the computer "answers" the inquiry.

Communication between humans and machine is both more complicated and more expensive because a high level of competence is necessary on the part of both sender and receiver. The human user must have additional skills (operating) in order to be able to decode messages.

The human-to-machine interface is also known as the „user interface" or „Computer–Human Interface" (CHI) and defines the „user view". For the average user this view is all of the system he sees (they believe it to be the system) and should be adapted as closely as possible to human thought and work processes.

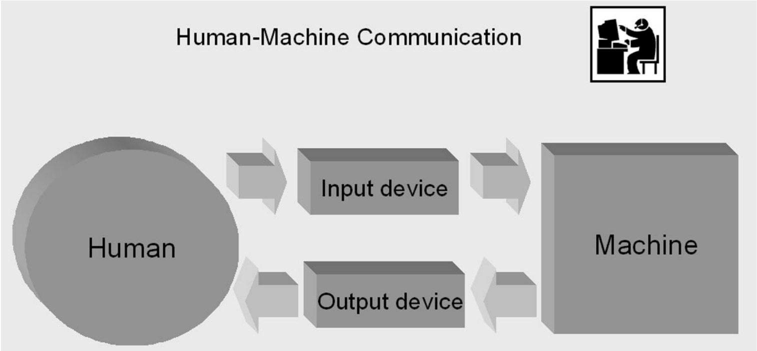


Fig. 1.24 In human-machine communication cognitive processes, such as perception, thought and learning, are particularly important

For example: in the following fields people are superior to computers:

- Sensitiveness for weak visual and auditory stimulation.
- Recognition of periodically varying, complex and fuzzy stimulation (for example: language).
- The ability to solve individual problems creatively.

Whereas computers are superior to people in the following fields:

- Detecting uniquely defined signals.
- Measuring, counting, computing and formal, logical operations.
- unfatiguable performance even with high signal density and distraction.

Performance = speed and quality with which a computer handles jobs

3.3.4 Machine–Machine Communication

Machine-to-machine communication is a type of communication with which two or more computers exchange data amongst themselves (without direct human intervention).

The term should not, however, disguise the fact that the communication is for the ultimate benefit of humans.

EDI, Electronic Data Exchange

A typical example of machine-to-machine communication is EDI, a system enabling computers to exchange financial and business documents without direct human intervention. For example: offers, receipts, bills etc. The files have a homogeneous format corresponding to a previously specified standard. They are machine-readable which makes it possible for the data to be processed automatically.

EDI is an **Electronic Commerce** application, with which *formalized* and *structured* files are exchanged between business partners.

Formalized files are file where the exact order in which information may appear is pre-specified.

An advantage of EDI lies in the fact that the workflow can be optimised due to automation and simplification. Initially individual enterprises developed their own EDI-standards, which soon led to compatibility problems.

The standard EDIFACT offers a series of international standards, for example, EDIFACT: Electronic Data Interchange For Administration, Commerce and Transport.

4 Module Summary

Multimedia Systems are interactive information systems. The principles of **Information Processing** (EDP) apply: Information is the result of physical signals varying in time or space. The physical carriers are the signals. The information lies in the *alteration* of a signal. Knowledge is applied information. A bit is the *smallest* quantity of binary information.

The mean information content of an information is termed **Entropy.** Redundancy, although reducing the information content, increases the reliability. The **Channel Capacity** is the maximum **Information Flow** that can be transmitted through a **Communication Channel** without error (for example: an *analog telephone* has a channel capacity of approximately 50 kbps).

SHANNONS interpretation of the term **Information** only really deals with the the concept of technical-mathematical communication: The meaning of the symbols is neglected. In order to understand and particularly to design multimedia information systems it is extremely important to be acquainted with the fundamentals of human communication. Communication is every exchange of information with a determinable content (News). We are dealing here with a *process* in which a **sender** and a **receiver** transmit a communication (message) over an information channel. A successful communication is only possible if the symbols used are accessible, and intelligible, to *both* sender and receiver.

Semiotics is defined as the Science of Signs and is divided into **Syntactics** (symbol ↔ symbol), **Semantics** (symbol ↔ meaning) and **Pragmatics** (symbol ↔ effect).

All communication processes between sender and receiver work on *three layers*. The lowest layer (the foundation or base) is the purely **syntactic layer**: the *transmission* of signals. The middle **semantic layer** compromises the *meaning* of the signals, while at the highest **pragmatic layer** the *effect* of the message on the receiver is registered.

It is possible to differentiate between *four types of communication*: **Human–to–Human Communication** (e.g. gestures, mimicry, sound, symbols or language) with the *special circumstances* of **Human–Machine–Human communication** (e.g. chat, eMail, IP telephony, teleconferencing), **Human–Machine communication** (Human–Computer Interaction, HCI; particularly important for the design of *interactive* multimedia systems) and **Machine-Machine Communication** (for example Electronic Data Exchange – EDI).

5 Module Supplement

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5.1.2 Articles in English

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5.1.3 German Books

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5.1.5 Journals

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Information and Software Technology | ISSN 0950-5849; electronic: 0950-5849 | Elsevier Science Ltd.

Information Communication and Society | ISSN 1369-118X; electronic: 1369-118X | Taylor & Francis Ltd.

Information Retrieval | ISSN 1386-4564; electronic: 1386-4564; combined: 1386-4564 |Kluwer Academic Publishers Group

Information Society | ISSN 0197-2243; electronic: 1087-6537|Taylor & Francis Ltd.

Information Systems Journal | ISSN 1350-1917; electronic: 1365-2575 | Blackwell Science Ltd

Information Systems Research | ISSN 1047-7047; electronic: 1047-7047; combined: 1047-7047| INFORMS Institute for Oprations Research

Information Technology and People | ISSN 0959-3845 | MCB University Press Ltd

International Journal of Cooperative Information Systems |ISSN 0218-8430 | World Scientific Publishing Co.

JIT – Journal of Information Technology |ISSN 0268-3962 | Taylor & Francis Ltd.

Journal of Information Science |ISSN 0165-5515; electronic: 0165-5515; combined: 0165-5515 | World Wide Subscription Service - Bowker Saur

Journal of Information Technology for Teacher Education | ISSN 0962-029X | Triangle Jour-

nals Ltd.

Journal of Intelligent Information Systems | ISSN 0925-9902 | Kluwer Academic Publishers

Multimedia Information and Technology | ISSN 1466-190X | Association for Information Management

Multimedia Systems | ISSN: 0942-4962; electronic: 1432-1882) | Springer Verlag KG

Multimedia Tools and Applications | ISSN: 1380-7501 | Kluwer Academic Publishers Group

New Review of Hypermedia and Multimedia – Applications and Research | ISSN: 1361-4568 | Taylor Graham Publishing – Journal Department

Problems of Information Transmission | ISSN 0032-9460 | Plenum Publishing Corporation

5.2 Internet Links

Up-to-date Internet Links for this module can be found on the homepage of this book **www.basiswissen-multimedia.at** (in English and German) under Volume 1: Technology, Module 1: Information and Communication Supplement.

5.3 Examination Questions

Question-Type 1: Yes/No (Dichotomy) :

01	Surprising, rare or new events have small information content.	❒ Yes ❒ No	
02	Information with the probability of “1” has the information content of “0”.	❒ Yes ❒ No	
03	Redundancy always means a loss of information and is therefore undesirable.	❒ Yes ❒ No	
04	The channel capacity is dependent on the information source and the transmission channel.	❒ Yes ❒ No	
05	SHANNON’S Theory of the Communication recognises the importance of the symbols used.	❒ Yes ❒ No	
06	Syntactics describes and analyses the relationships between different symobols.	❒ Yes ❒ No	
07	According to WATZLAWICK, every communication has an aspect of content and an aspect of relationship.	❒ Yes ❒ No	
08	Communication via eMail is assigned to the field of human-machine-human communication.	❒ Yes ❒ No	
09	Human-Machine communication is easier due to the fact that competence in communicating is less importnt.	❒ Yes ❒ No	
10	Software-ergonomics and usability are important fields of research within HCI.	❒ Yes ❒ No	

Question-Type 2: Multiple Choice:

01	In our modern information society ... ❒ a) ... 75 % of employees work with information, not with material. ❒ b) ... 50 % of the production costs are booked to information. ❒ c) ... computer science and information technology are basics. ❒ d) ... we live increasingly in a Society of Knowledge.	
02	Information is ... ❒ a) ... a statement or message that tells something new. ❒ b) ... a space or time variant series of physical signals. ❒ c) ... the same as knowledge – forward looking and probabilistic. ❒ d) ... a modification process that leads to an increase at knowledge.	
03	The information content of a message ... ❒ a) ... according to SHANNON, includes the meaning of the information. ❒ b) ... is smaller the bigger the surprise value. ❒ c) ... with discreet signs, is the result of the entire character set *s*.. ❒ d) ... is dependent on the occurrence probability of the signs.	
04	In the information theory ... ❒ a) ... a higher entropy value means a greater insecurity. ❒ b) ... redundancy means a desired information increase. ❒ c) ... redundancy means an unwanted information reduction. ❒ d) ... redundancy means a decrease in the mean information content.	
05	The channel capacity ... ❒ a) ... is the maximum flow of information F transmittable over a channel. ❒ b) ... of an analog telephone is approximately 300 kbps. ❒ c) ... is determined by the bandwidth B. ❒ d) ... is independent of the characteristics of the information source.	
06	Semiotics ... ❒ a) ... deals exclusively with human speech. ❒ b) ... examines the relationship between symbols in the sub-division Pragmatics. ❒ c) ... examines symbols and their importance on the semantic level. ❒ d) ... is the basis of research into communication.	
07	According to WATZLAWICK ... ❒ a) ... every form of *relationship* has an influence on human communication. ❒ b) ... every communication has a content and a relationship. ❒ c) ... there is no such thing as an "objective reality". ❒ d) ... a linear transmitter-receiver model is the basis of communication.	
08	HCI ... ❒ a) ... is fundamentally more extensive than other forms of communication. ❒ b) ... deals with usability and software ergonomics. ❒ c) ... handles cognitive processes. ❒ d) ... concentrates on machine intern communication.	

5.4 Answers

Correct answers to Group „Question Type 1“:

01 No; 02 Yes; 03 No; 04 No; 05 No; 06 Yes; 07 Yes; 08 Yes; 09 No; 10 Yes;

Correct answers to Group „Question Type 2“:

01 a) b) c) d); 02 a) b) d); 03 c) d) ; 04 a) d); 05 a) c) d) 06 c) d); 07 a) b) c);
08 a) b) c)

5.5 Hands-On: Exercises

- Set up a chart showing the theories of SHANNON and WATZLAWICK in tabular form. Which differences do they have? Which characteristics do they share?
- Search for information about the term „Information“ in the Web. Compare the different viewpoints and definitions.
- Look around you. Which sources are information in your vicinity? Determine their channel capacities and bandwidths!

5.6 Themes for Debate

- One person takes the role of SHANNON, another the role of WATZLAWICK. Discuss the advantages and disadvantages of your approach. Allow the „public“ to ask questions during your debate.
- Discuss the aspects of the information theory and it's application to your language. What would be the result of all characters/symbols being equally necessary, no redundancy.
- Speculate about the future of communication. Which new forms of information and communication will exist in the future and what do the current problems originate.

5.7 Timeline: Information and Communication

800 B.C.: Torch telegraphy as communication method in Greece.

500 B.C.: AISCHYLOS describes Greek fire telegraphy.

490 B.C.: Persia has an organized communication system (Torch telegraphy).

350 B.C.: AENEAS describes a hydraulic synchronous telegraph.

100 A.D.: The Romans have a functioning „Internet“, the cursus publicus: Information is sent over distances of up to 300 km (approx. 190 miles) in 24 hours (Relay system).

1450: GUTENBERG: Beginning of the information age.

1665: First periodic news paper in Paris.

1794: Fast communication: Optical telegraphy (CHAPPE Brothers).

1837: COOKE and WHEATSTONE test pin telegraphy.

1844: SAMUEL MORSE develops the morse code for telegraph communication.

1876: GRAHAM BELL receives a patent for speech transmission (Telephone).

1897: MARCONI succeeds in the first radio-telegraphic communication.

1920: The world's first public radio broadcasting in Koenigs-Wusterhausen (Germany).

1935: The world's first regular, public channel service in Berlin.

1941: The world's first program controlled computer from ZUSE (Germany).

1956: First educational Television Programme in Chicago (with final examination).

1962: The first communications satellite TELSTAR I goes into orbit.

1970: Information transmission via optical fiber cables.

1980: Public Picture Transmission Systems (BTX, German for Bildschirm-Text).

1981: Increasing ownership of personal computers (PC's)

1982: Informations system MUPID (Austria).

1983: Start of the first European communications satellite (ECS).

1984: First electronic newspaper.

1985: First video conference.

1990: Begin of the digital car phone.

1992: Multimedia-Systems on CD-ROM.

1995: Exponential growth of the world wide web (WWW) proving as the greatest information system in the history of mankind.

2000: Broad-band satellite communication.

5.8 Glossary

ASCII **A**merican **S**tandard **C**ode for **I**nformation **I**nterchange is the most common format for text files in computers and on the Internet. In an ASCII file, each alphabetic, numeric, or special character is represented with a 7-bit binary number (a string of seven „0" or „1"). 128 possible characters are defined.

Alphabet is a set of letters or other characters with which one or more languages are written esp. if arranged in a customary order, for example: the latin alphabet (ABC), Morse alphabet (wireless transmission), ASCII-Text (Computer text), Flag alphabet (Nautical), sign language (Deaf), Braille alphabet (Blind).

Baud was the prevalent measure for data transmission speed until replaced by a more accurate term: bits per second (bps). One baud is one electronic state change per second. Since a single state change can involve more than a single bit of data, the bps unit of measurement has replaced it as a better expression of data transmission speed. Baud was named after the French engineer, BAUDOT. It was first used to measure the speed of telegraph transmissions.

bit **bi**nary digi**t**, smallest unit in digital technology („0" or „1").

bps **b**its **p**er **s**econd, transmission speed, also: bit/s.

Byte **b**inar**y** digi**t** **e**ight, information unit (1 Byte = 8 bit).

CCITT **C**omité **C**onsultatif **I**nternationale de **T**élégraphie et **T**éléphonie; now also known as the ITU-T (Telecommunication Standardization Sector of the International Telecommunications Union), is the primary international body for fostering cooperative standards for telecommunications equipment and systems. It is located in Geneva (Switzerland).

EDI **E**lectronic **D**ata **I**nterchange.

Entropy originally a term in Thermodynamics. In data communications, the term entropy refers to the relative degree of randomness. The higher the entropy, the more frequent are signalling errors. Entropy is directly proportional to the maximum attainable data speed in bps (bits per second). Entropy is also directly proportional to noise and bandwidth. The entropy in a signal is inversely proportional to compressibility; the greater the entropy, the smaller the factor by which the data can be compressed. Entropy also refers to disorder deliberately added to data in certain encryption processes.

HCI **H**uman-**C**omputer **I**nteraction, sometimes called CHI (Computer-Human Interaction), but the „Human“ should come first.

ISO **I**nternational **S**tandards **O**rganization.

Pragmatics a branch of semiotic that deals with the relation between signs or linguistic expressions and their users.

Redundancy is the part of a message that can be eliminated without loss of essential information („longwindedness“). Used for fail safe operation and error detection.

Semantics is a branch of semiotics dealing with the relations between signs and what they refer to and including theories of denotation, extension, naming, and truth.

Semiotics is the theory of signs and symbols that deals with their function in both artificially constructed and natural languages and comprises syntactics, semantics, and pragmatics.

Sign is a fundamental linguistic unit that designates an object or relation or has a purely syntactic function.

Signal is the physical carrier of information. Signals are physical measurements for example light impulses, voltage alterations, etc. Signals are transmitted always through an energetic process.

Symbol can be an act, sound, or object having cultural significance and the capacity to excite or objectify a response.

Syntactics is a branch of semiotics that deals with the formal relations between signs or expressions in abstraction from their signification and their interpreters.

Unicode is an entirely new idea in setting up binary codes for text or script characters (Unicode Worldwide Character Standard). Refer to ASCII.

Workflow is a term used to describe the tasks, procedural steps, organizations or people involved, required input and output information, and tools needed for each step in a business process (used in EDI-Systems).