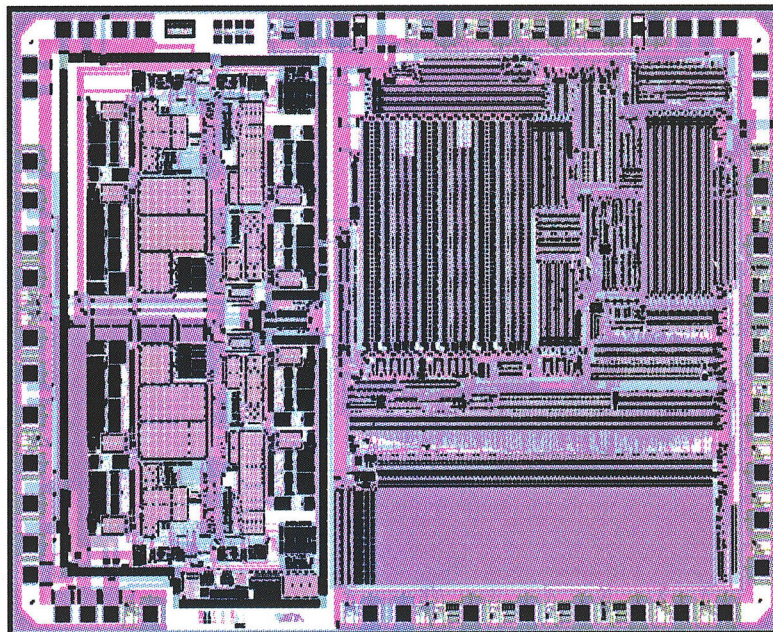


DIGITAL SIGNAL PROCESSING FROM THEORY TO TOOL



Tampere University of Technology
Institute of Signal Processing

Dramatic change in the role of the researcher

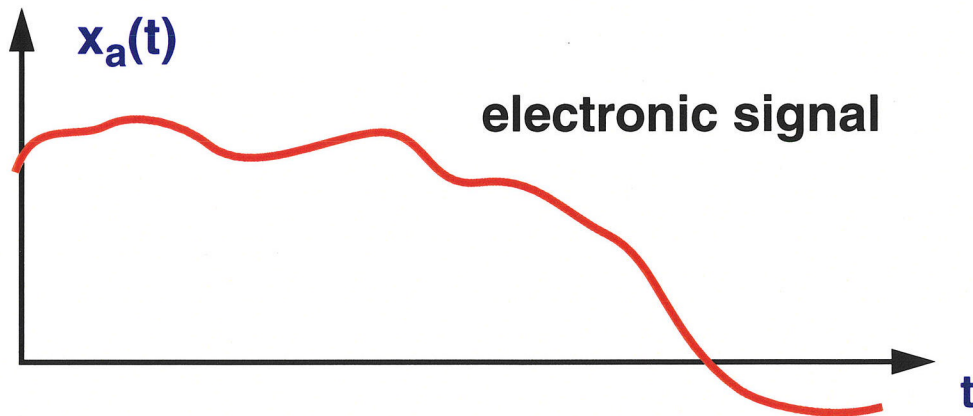
- **Twenty years ago the researcher was a theoretic who used mainly applied mathematics.**
- **Nowadays, when developing DSP algorithms, the constraints of the application and the implementation must be taken into account in order to arrive at good overall products.**
- **Team work is nowadays of great importance in both basic research and in applied research: A single person is no more capable of deeply understanding all the sub-topics needed in the reserach work.**

Recording the concert of Leningrad Cowboys and the Red Army chorus into a CD

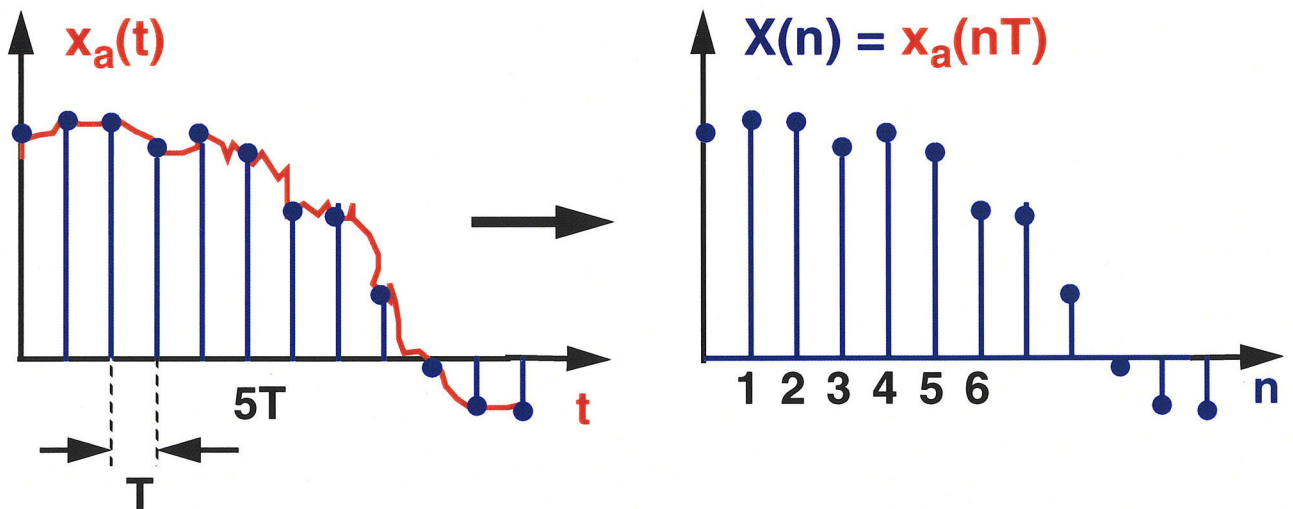


Generation of various bitstreams

- For each soloist, for each instrument, for the chorus, and for the audience, there are one or more microphones.
- Each microphone converts the pressure wave into an electronic signal:

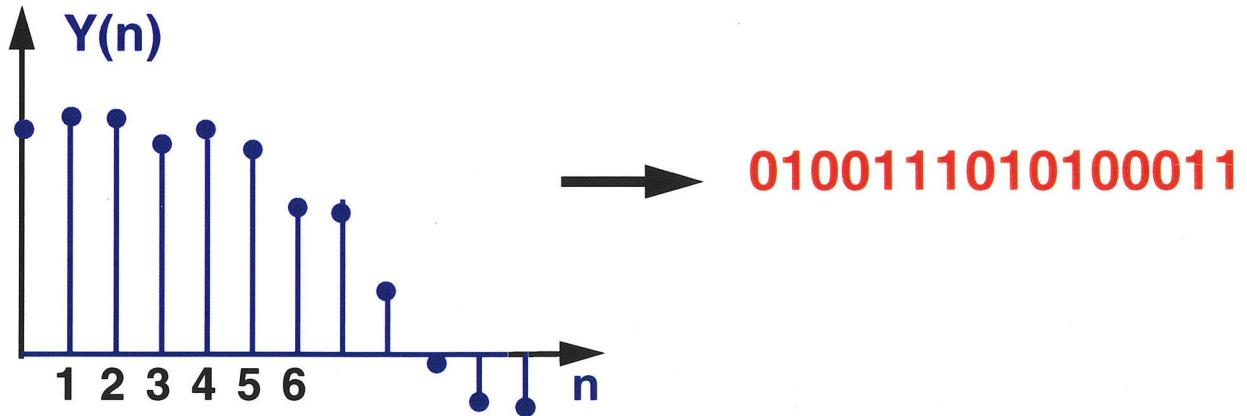


- The values of this signal are measured at the given sampling period: A sequence of signal values is generated:



Generation of various bitstreams

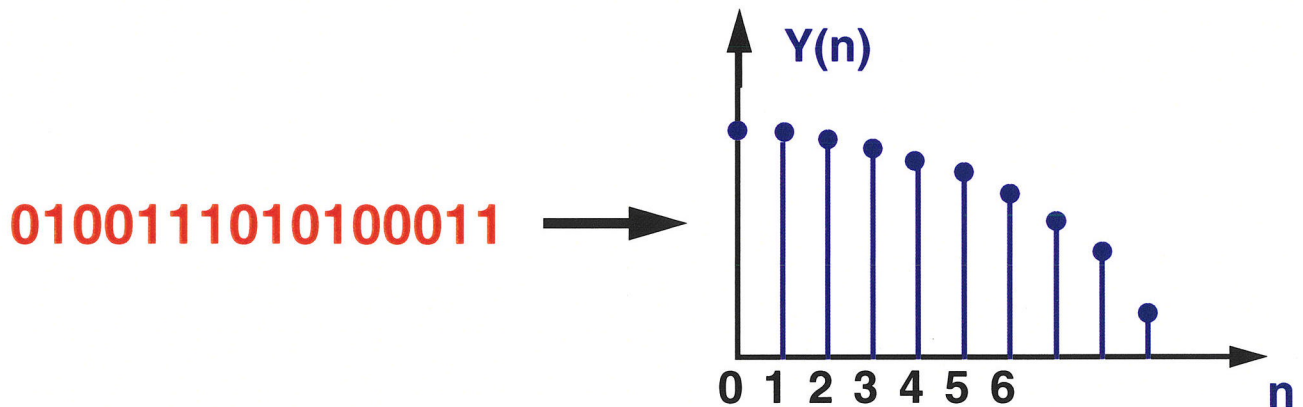
- The resulting sequence is coded into a bitstream:



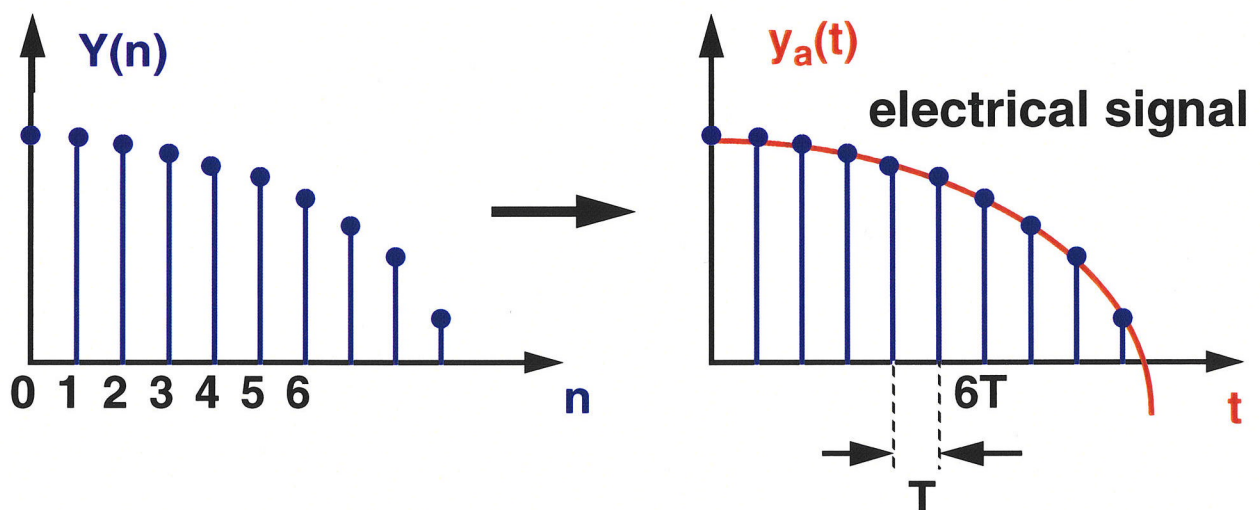
- All the bitstreams are put into the memory for the further processing.

Generation of two pressure waves from the CD

- The CD contains two bitstreams in order to generate the stereo signal to our ears.
- The bitstreams are converted to sequences of numbers:



- After this, we generate two electrical signals that are converted into two pressure waves using loudspeakers.



- Our ears recognize these pressure waves as a concert.

Requirements for generating the stereo feeling

- **Provided that the two bitstreams are properly generated based on the above-mentioned several bitstreams and the loudspeakers are properly placed, we are getting a feeling that we attending the concert.**
- **The main goal is to get into our ears two pressure waves in such a way that finally we feel in the same manner as being present in the concert.**
- **Good CD's are generted in studios using experts in music and with the aid of digital signal processing.**

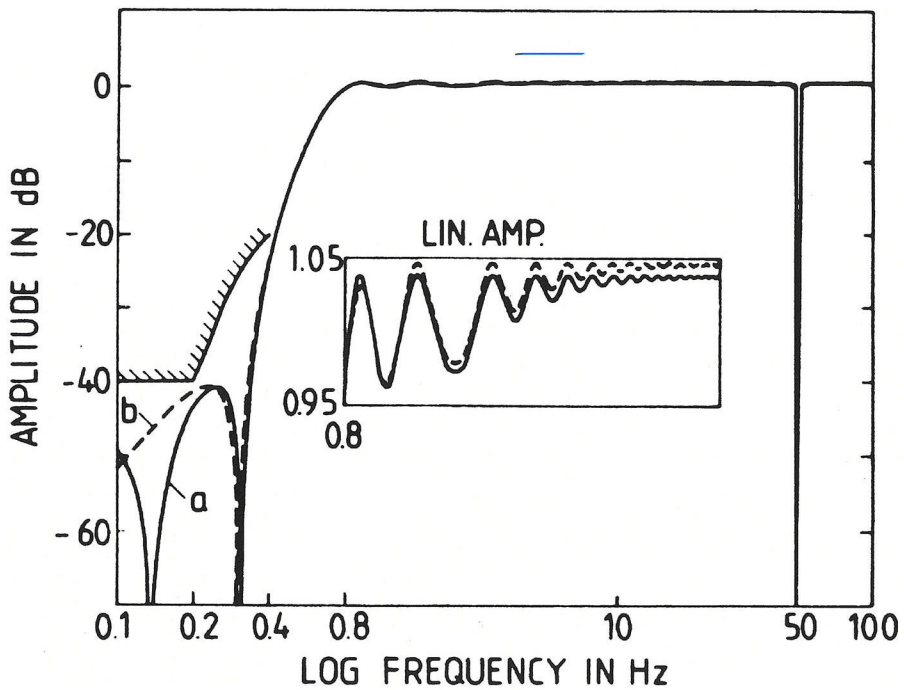
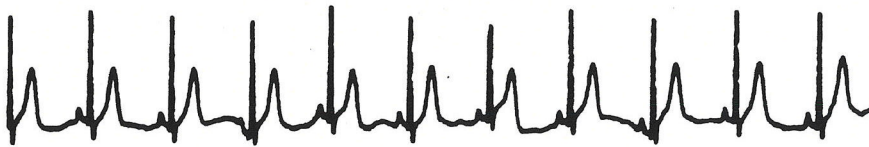
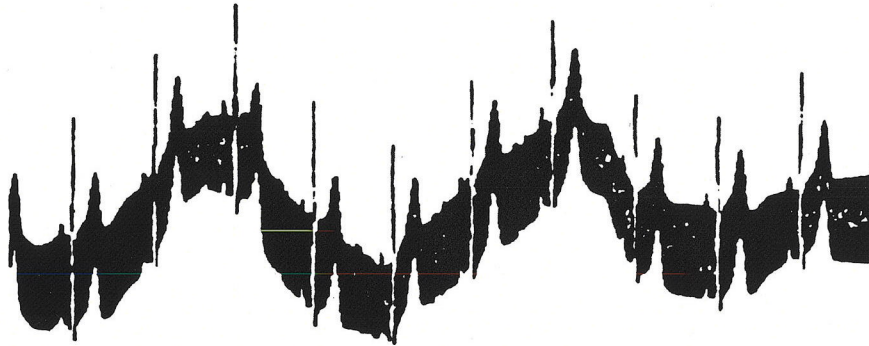
Various Digital Systems

- 1) Removal of interferences, noise, and undesired components from digital signals and images:**
 - a) Linear digital filters**
 - b) Adaptive filters**
 - c) Nonlinear digital filters**

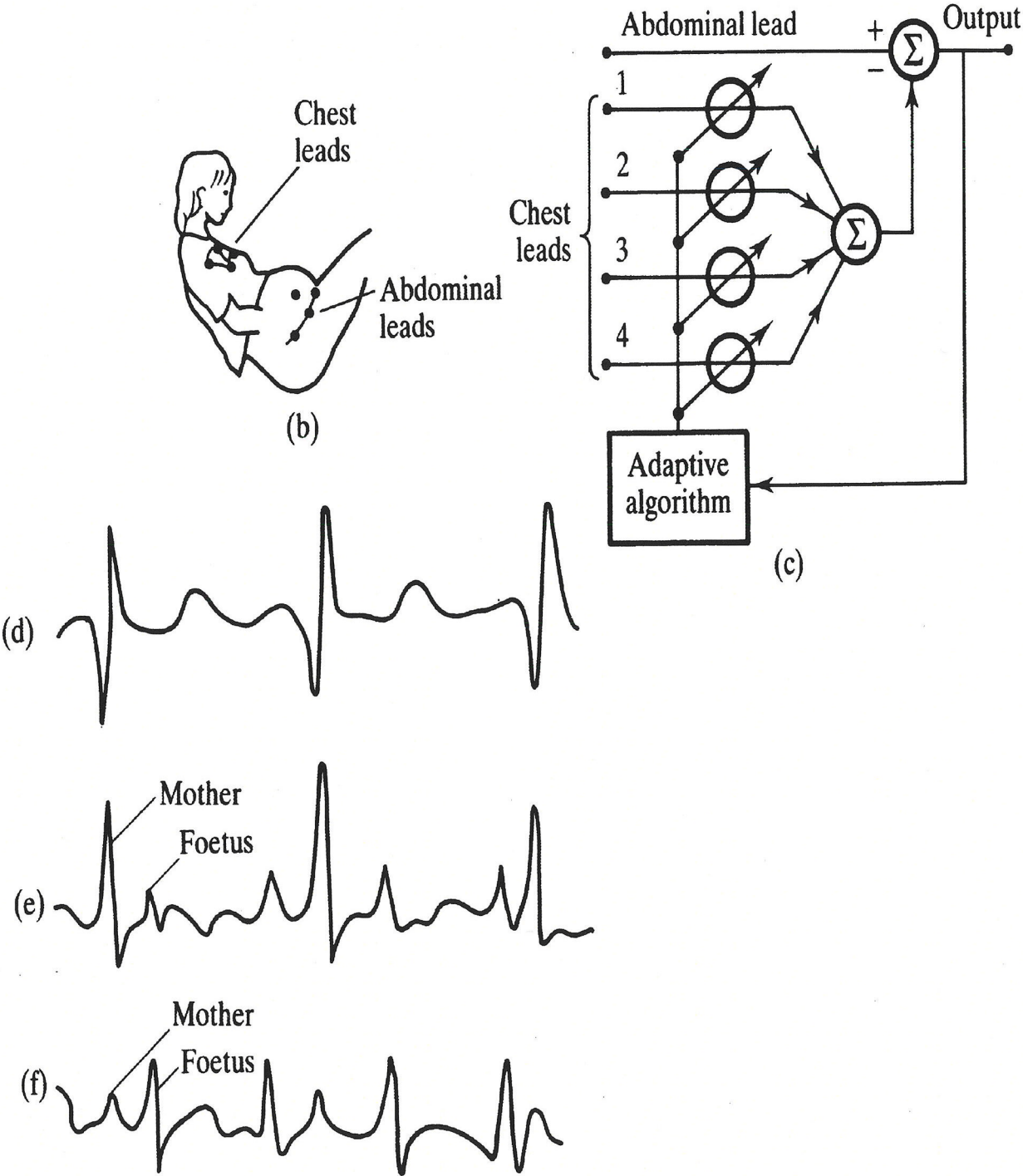
- 2) Transferring signals, images, and videos into the memory as a bitstream after coding and compression:**
 - a) CDs: Music**
 - b) CD-Roms: Sequence of images and music**
 - c) DVD-Roms: Films and videos**

- 3) Transferring signals, images, and videos as a bitstream either using a wireline or wireless:**
 - a) Digital radio and TV are under development**
 - b) For one analogTV channel there is space for six digital channels.**
 - c) The reliability of telecommunications is improving and the versatility of the components is getting higher when the parts of the overall systems are implemented using DSP algorithms.**

Removal of the line frequency interference and breathing artifacts from the ECG-signal



Use of adaptive filtering for finding the ECG-signal of the foetus



Various Digital Systems

- 4) Analysis and search of special features from signals and images:**
 - a) Easier to find out diseases, like cancer**
 - b) Quality control in the industry**
 - c) Pattern and speech recognition**

- 5) Enhancement or improvement of signals and images:**
 - a) Earlier we had an example for improving an image**
 - b) Restoration of old recordings and films**

- 6) Generation of artificial signals, images, and films**
 - a) Synthetic speech and music**
 - b) Use of additional effects in films**

Some of the main advantages of DSP

- 1) Versatility**
- 2) Easy to copy identical systems: VLSI-circuits**
- 3) Accuracy and reliability**
- 4) Small size and low cost of the systems**

Challenges for the future

- 1) **Virtual reality:** The miners will be replaced by persons that work at three-dimensional terminals and control robots.
- 2) **Global positioning systems:** It is easy to find in the forest a secret place with plenty of delicious berries.
- 3) **Video phone:** The picture quality is improving.
- 4) **Videoconferences:** The picture quality is improving.
- 5) **Communication between the human being and the computer:** speech will be used more in the future.
- 6) **Telecommunications:** The trend is to replace analog circuits by their digital counterparts.

In the high-frequency parts of telecommications systems there is still a need to use analog circuits: **Universities should still educate experts in analog signal processing!**