

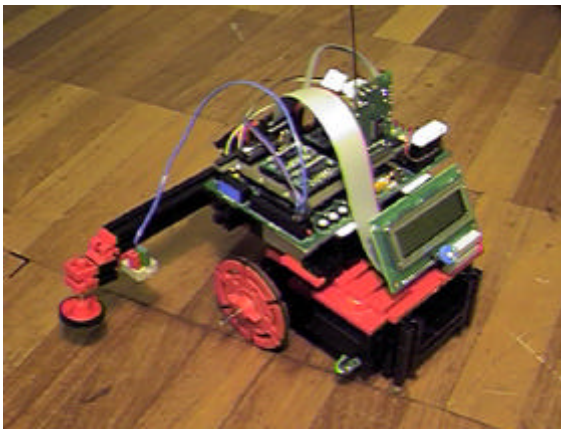
Embedded Systems

- Agenda:
 - What is an embedded system?
 - Example - mobile phone handset
 - GSM cellular telephony
 - handset design
 - System-on-Chip (SoC) design
 - designing embedded systems

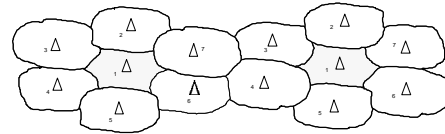


What is an embedded system?

- A computer the user can't program?
 - the computer is just a system component
 - often the program is fixed
 - interacting in real-time with external events
- sometimes the distinction is fuzzy
 - is a PDA an embedded system?
 - is a games console an embedded system?
- 90% of computers are embedded!



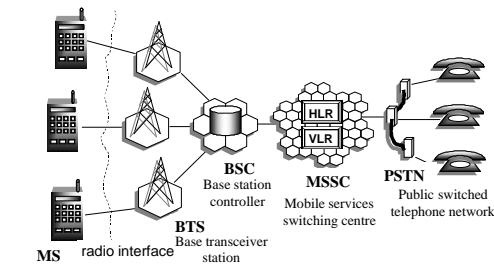
The Cellular Concept



- Coverage area of a transmitter called a cell
- Radio Propagation
 - power decreases by $1/\text{distance}^2$ (ideal), $1/\text{distance}^4$ (real).
- Spectrum scarcity, so reuse frequencies

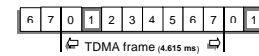


GSM Architecture

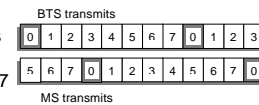


Radio Interface

- **Time Division Multiple Access (TDMA)**



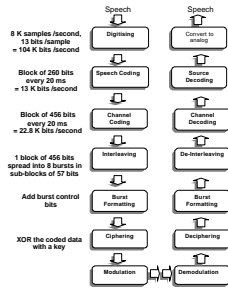
- Assigned spectrum is divided into 8 time slots, numbered 0 to 7 (called a Frame)
- Each time slot is assigned to an individual user
- MS & BTS do not transmit at the same time
- The radio transmission during a time slot is called a *burst*



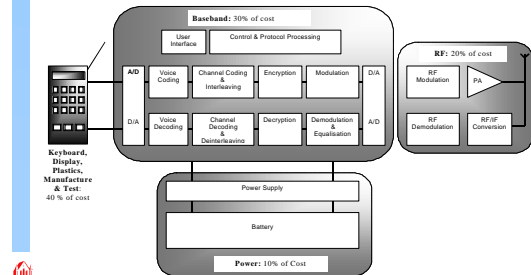
Operation of the Handset

Transmit speech

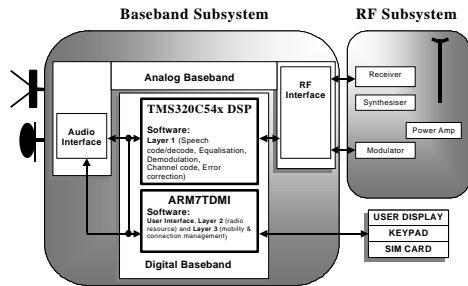
- analog voice is digitised and band-limited
- data rates reduced by compression
- encode then interleave to reduce transmission errors
- add burst information and cipher for security
- convert up frequency and transmit



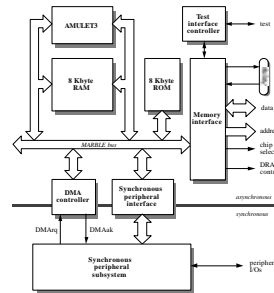
Partitioning the design



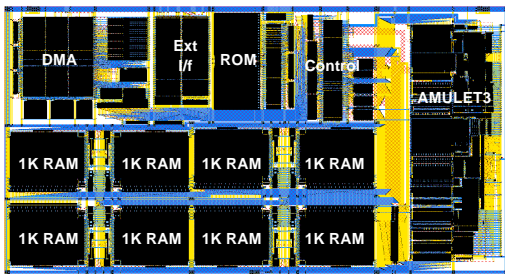
A Typical Implementation



System-on-Chip: e.g. AMULET3i



AMULET3i - physical SoC layout



Embedded systems: conclusions

- design constraints differ
 - especially in real-time performance
- general-purpose machines contain embedded subsystems:
 - disk, keyboard, battery, modem, ...
- SoC designs feature strongly
- 90% of all computers are embedded
 - a lot of folk are employed making them