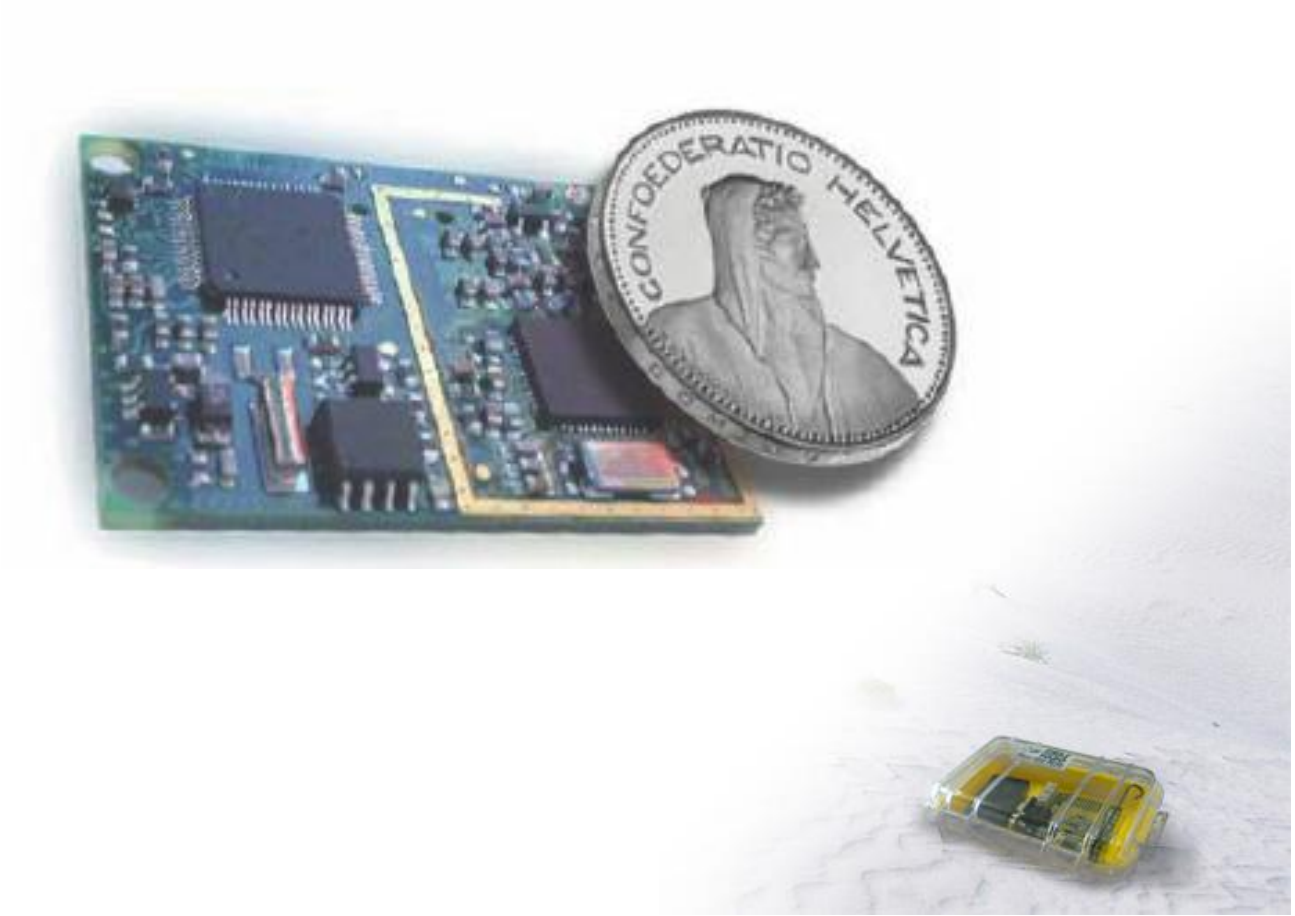
TinyOS 2.x & nesC

Chapter X

Sensor Nodes

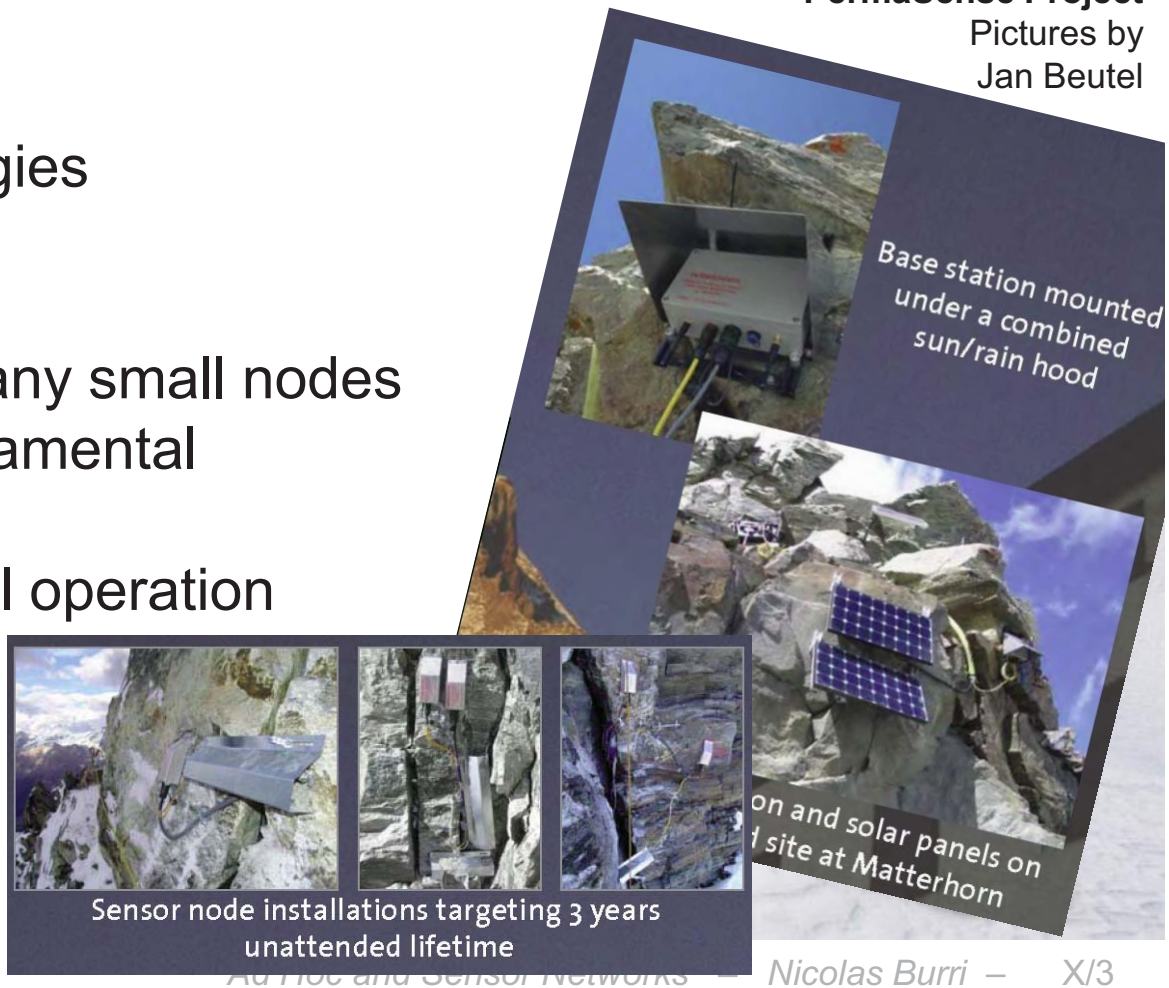
- System Constraints
  - Slow CPU
  - Little memory
  - Short-range radio
  - Battery powered



Operating System Requirements

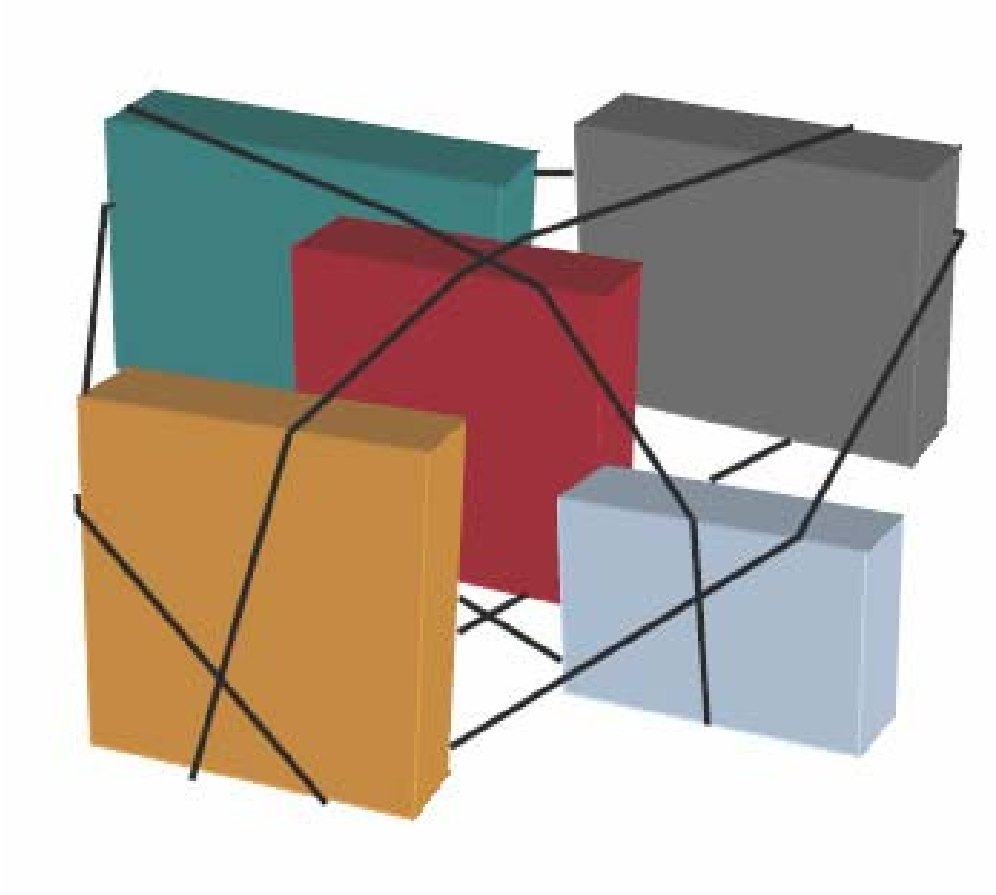
- Measure real-world phenomena
  - Event-driven architecture
- Resource Contraints
  - Hurry up and sleep!
- Adapt to changing technologies
  - Modularity & re-use
- Applications spread over many small nodes
  - Communication is fundamental
- Inaccessible location, critical operation
  - Robustness

PermaSense Project
Pictures by
Jan Beutel



TinyOS

- TinyOS consists of a scheduler & graph of components

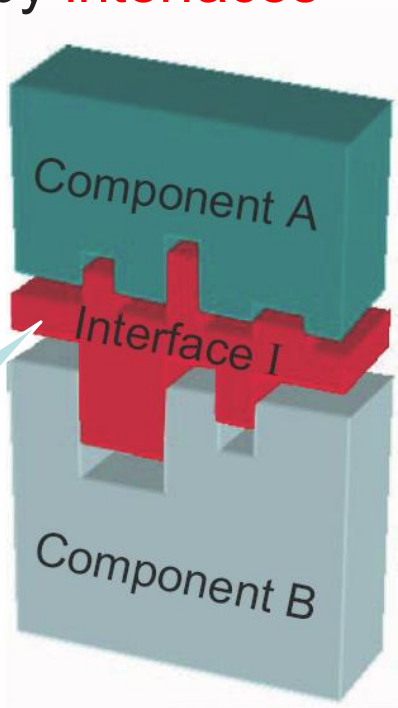


Programming Model

- Separate construction and composition

provide „hooks“ for component wiring

- Programs are built out of components connected by interfaces
- Two types of components:
  - Modules: Implement program logic
  - Configurations: Wire components together
- Components use and provide interfaces

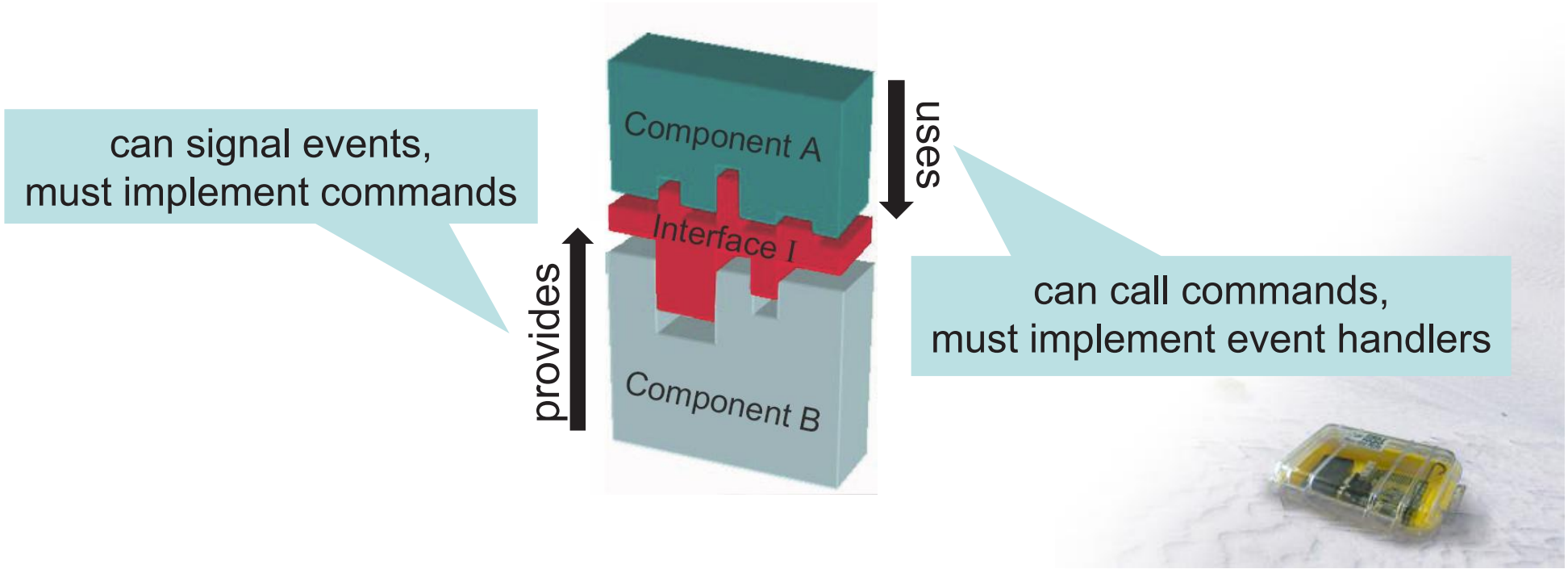


Interfaces are bidirectional

Programming Model

- Interfaces contain definitions of
  - Commands
  - Events

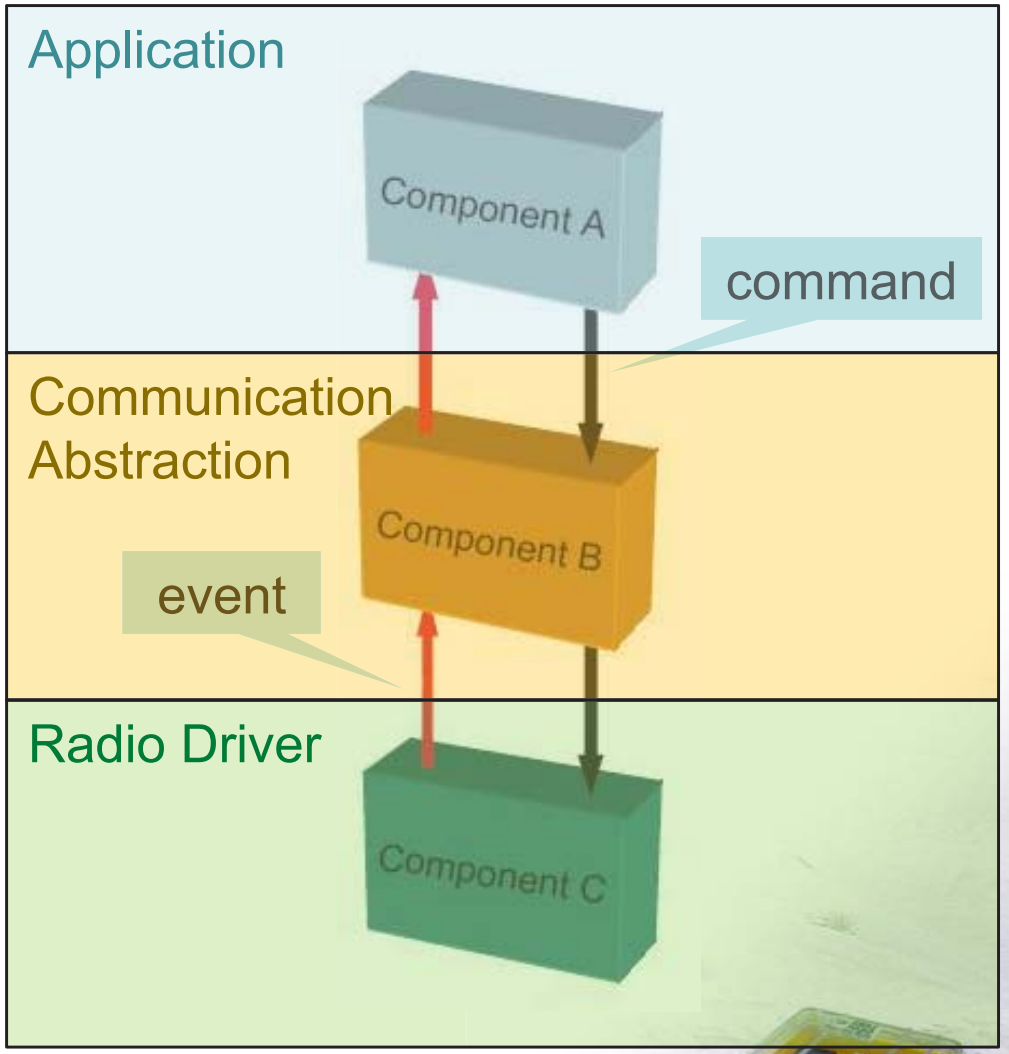
- Components implement the events (event handlers) they use and the commands they provide



Programming Model

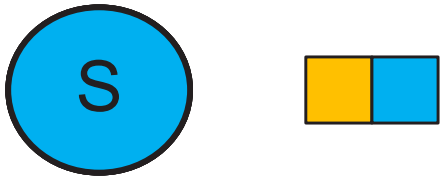
- Components are wired together by connecting interface users with interface providers
- Commands flow downwards
  - Control returns to caller
- Events flow upwards
  - Control returns to signaler
- Commands are non-blocking requests

Modular construction kit



Concurrency Model

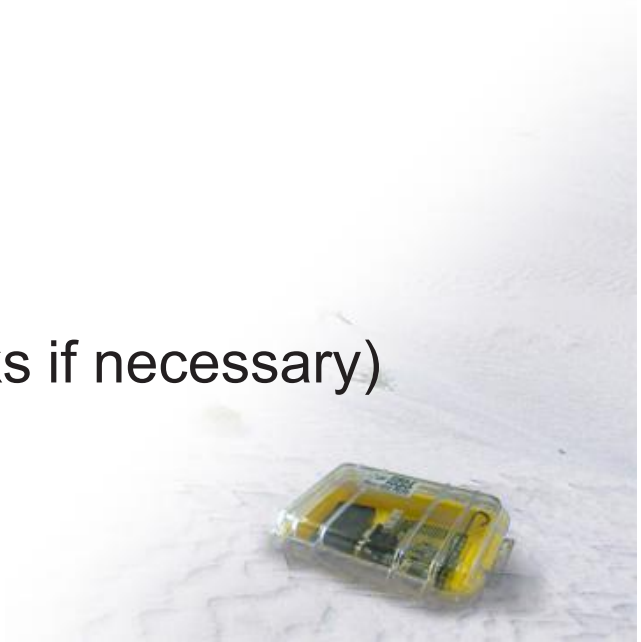
- Coarse-grained concurrency only
  - Implemented via tasks



- Tasks are executed sequentially by the TinyOS scheduler
  - "Multi-threading" is done by the programmer
  - Atomic with respect to other tasks (single threaded)
  - Longer background processing jobs

- Events (interrupts)
  - Time critical
  - Preempt tasks
  - Short duration (hand off computation to tasks if necessary)

watch out for data races



Memory Model

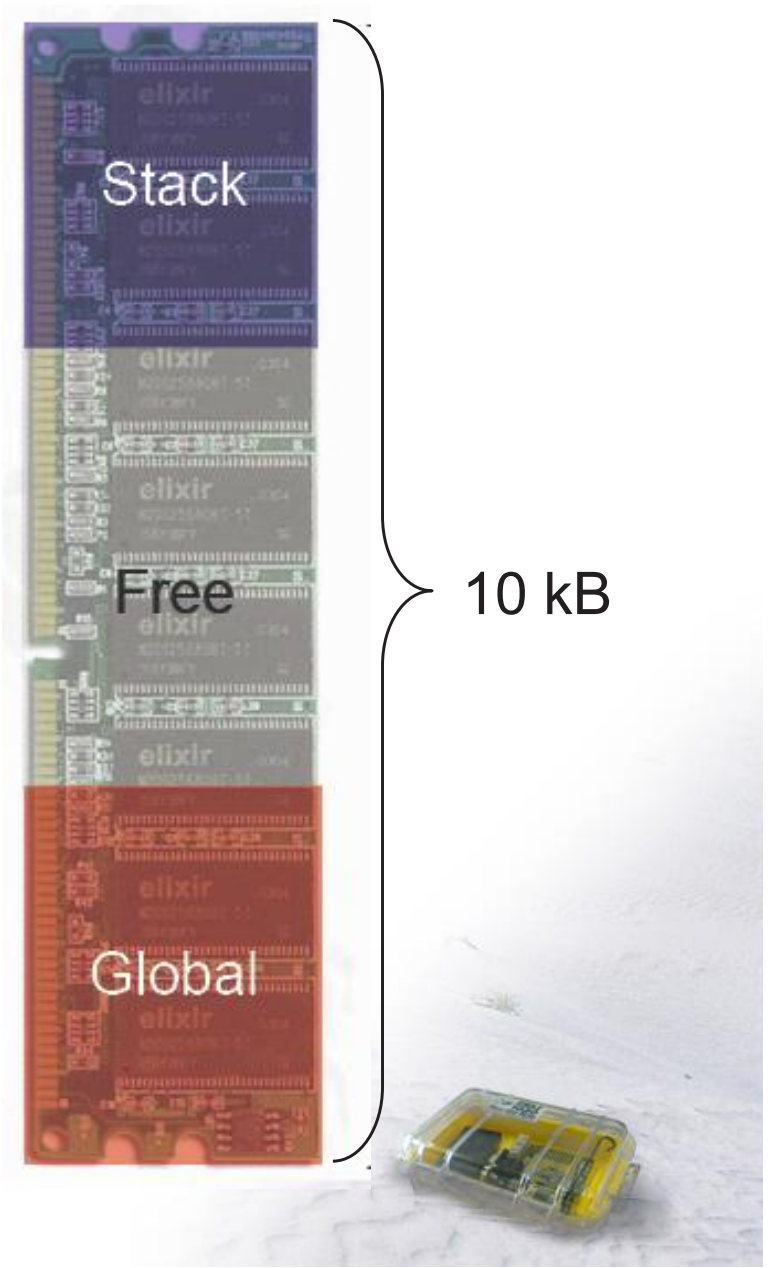
- Static memory allocation
  - No heap (malloc)
  - No function pointers

bye-bye complex data structures

- Global variables
  - One namespace per component

- Local variables
  - Declared within a function
  - Saved on the stack

- Conserve memory
- Use pointers, don‘t copy buffers



TinyOS Distribution

- TinyOS is distributed in source code
  - nesC as programming language

- Nested C (nesC)
  - Dialect of C
  - Embodies the structural concepts and execution model of TinyOS
    - Module, configuration, interface
    - Tasks, calls, signals
  - Pre-processor produces native C code

- nesC limitations
  - No dynamic memory allocation
  - No function pointers

nesC – Hello World

```
configuration BlinkAppC{
}
implementation {
  components MainC, BlinkC, LedsC;
  components new TimerMilliC()
                as Timer0;

  BlinkC -> MainC.Boot;

  BlinkC.BlTimer -> Timer0;
  BlinkC.Leds -> LedsC;


}
```

```
module BlinkC {
  uses interface Timer<TMilli>
               as BlTimer;
  uses interface Leds;
  uses interface Boot;
}
implementation{
  event void Boot.booted() {
    call BlTimer.startPeriodic(1000);
  }
  event void BlTimer.fired() {
    call Leds.led0Toggle();
  }
}
```

The End

Thanks to Pascal von Rickenbach for many of the slides