Functional Programming^{XP}

The Industrial Experience

OSTROVSKY
RESEARCH INSTITUTE

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- M.Sc. – Comenius University, Bratislava
- Ph.D. – Chalmers
- Post-doc – Chalmers
- System Designer – Dfind IT
  - On assignment for Ericsson
- Design Architect
  - On assignment for Ericsson

The Chalmers Years

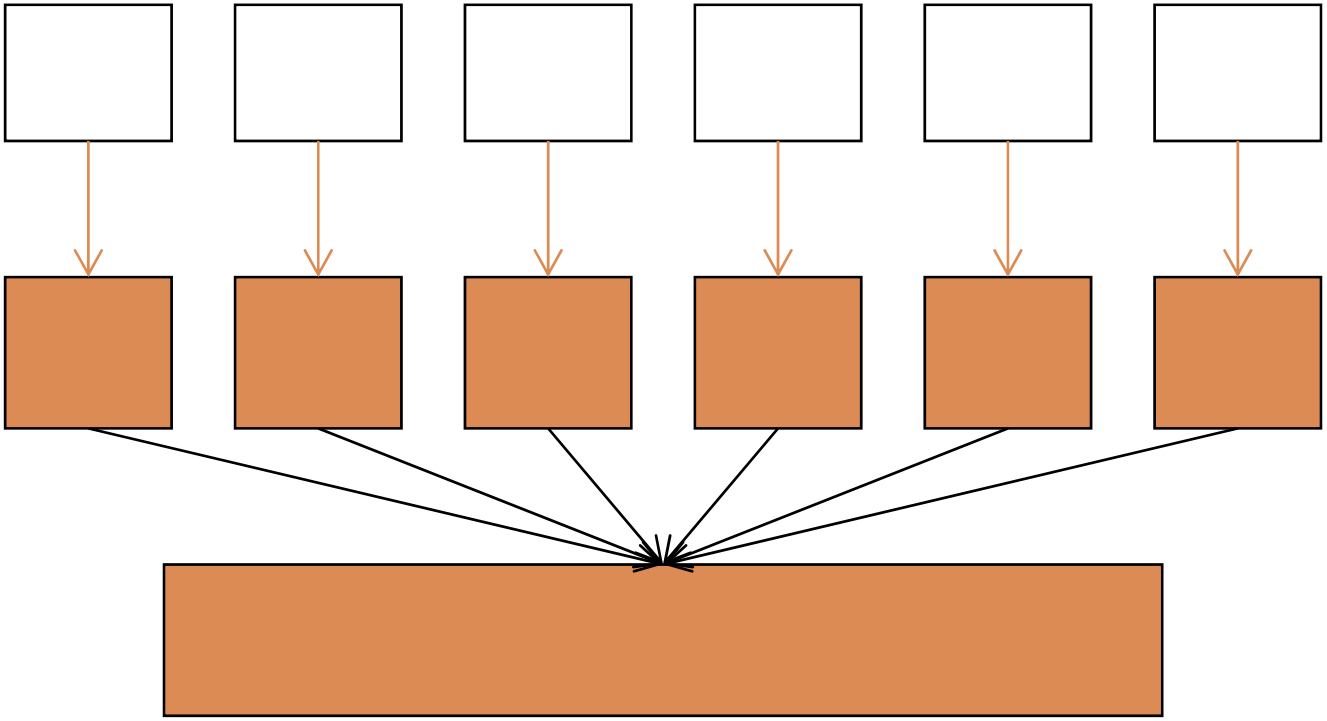
- Research in static analysis of concurrent programming languages
  - Type systems
  - Protocol analysis
- Main course responsible
  - Concurrent Programming Course – TDA381
  - Developed the course between 2005 and 2010

The Language & Paradigm Nerd

- Basic
- Pascal
- C/C++
- Scheme
- SmallTalk
- Java
- JR (MPD)
- Haskell
- Erlang
- Ocaml
- LaTeX
- VAX assembler
- Trilogy
- Ada
- Agda
- ATL
- My own languages

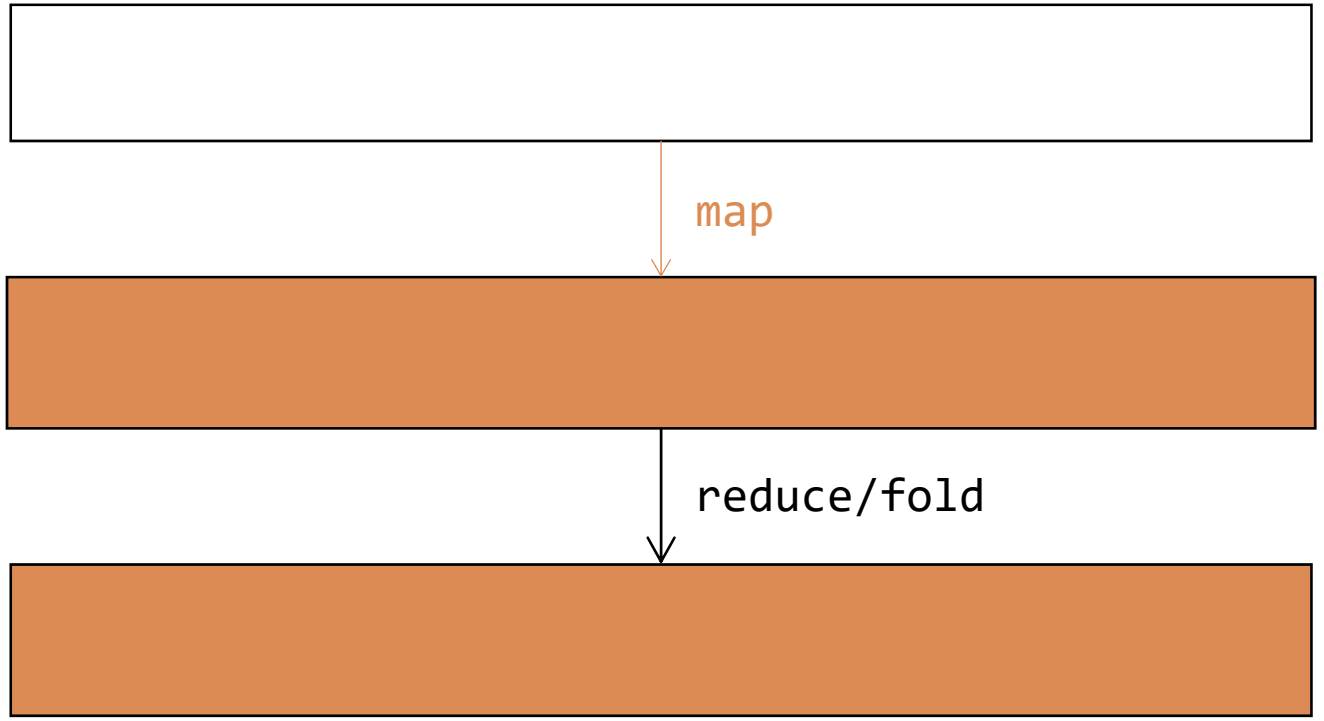
What is Programming?

- Manipulation of Structures



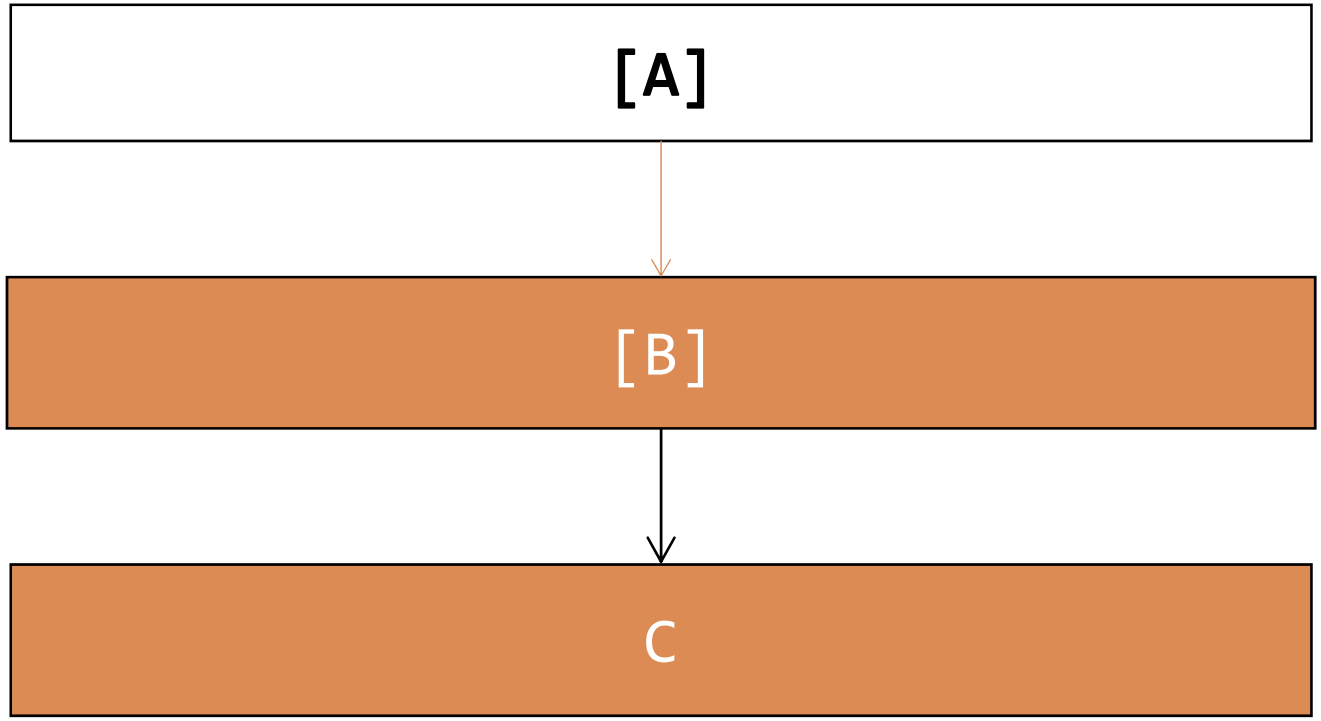
Compositions

- Functions

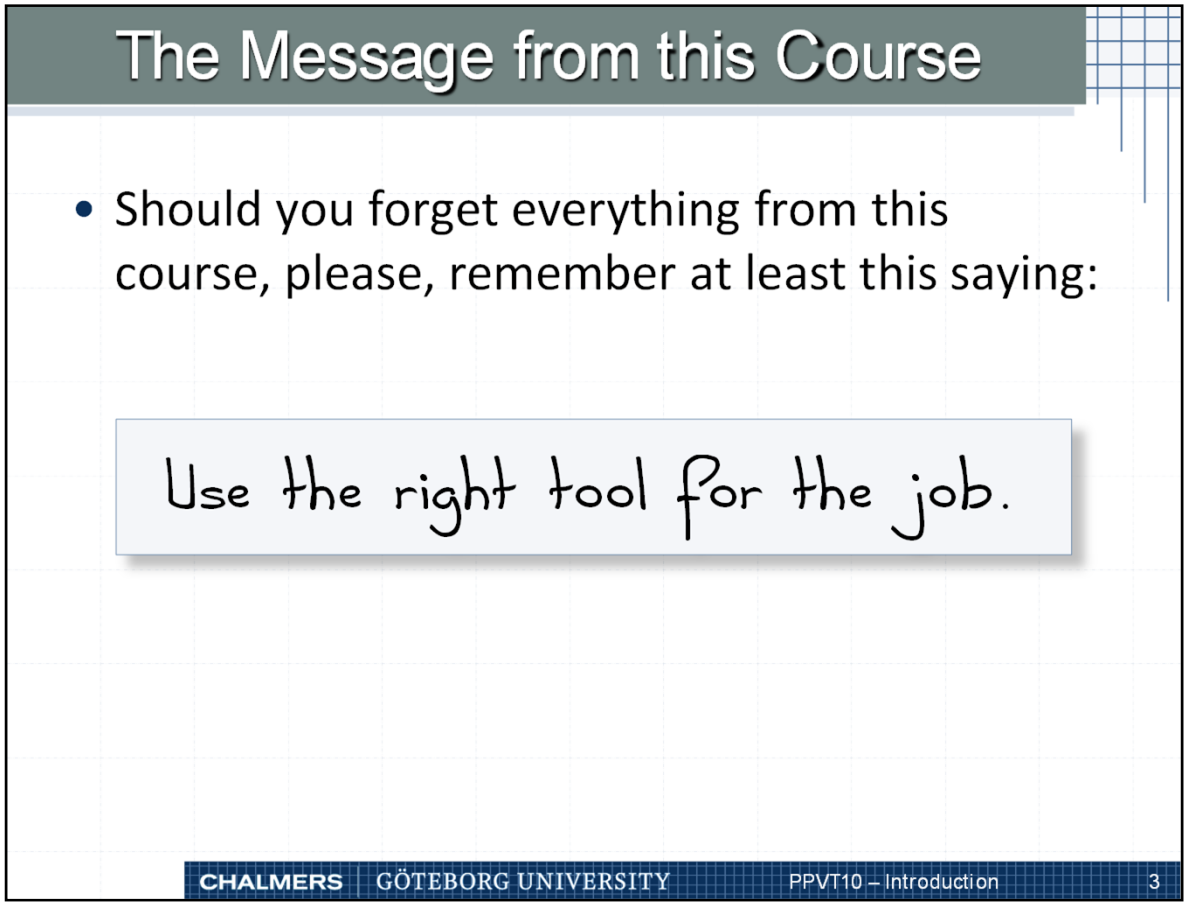


Structures

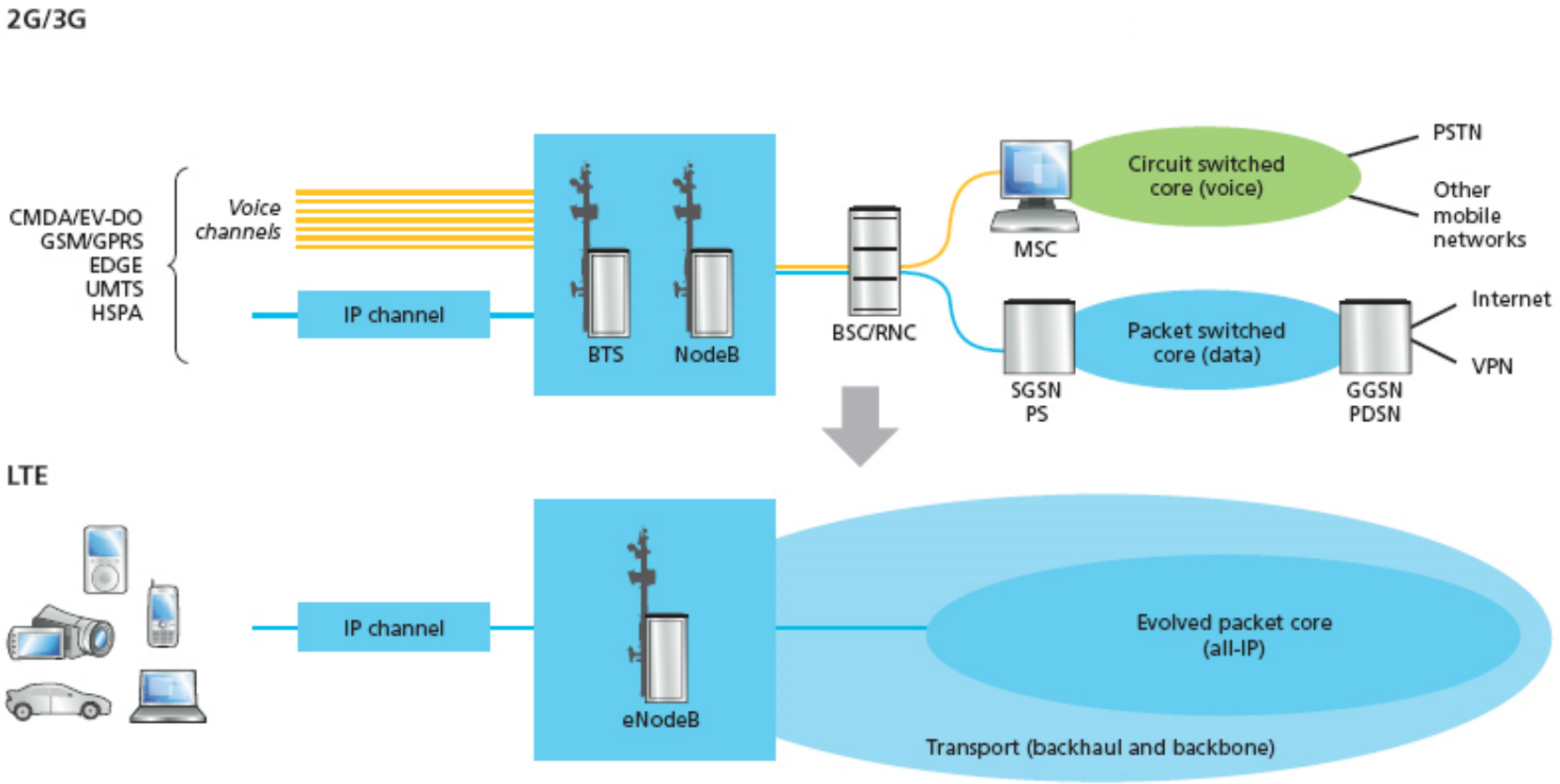
- Types



My Favourite Slide



Mobile Telecom Network



Mobile Telecom Standards

- Interoperability is essential
- The Internet Engineering Task Force
  - Develops and promotes voluntary Internet standards
  - Request for Comments (RFC)
- 3rd Generation Partnership Project (3GPP)
  - Defines telecom standards

Packet Core Network

- Ericsson SGSN-MME
  - SGSN – Servicing GPRS Support Node (2G/3G)
  - MME – Mobility Management Entity (4G)
  - Control signalling
  - Admission control, Authentication
  - Mobility, roaming
  - Payload transport (not in 4G or 3GDT)

SGSN-MME MkVI

- 3 sub-racks
- 21 blades (2+19)
- 2 core PowerPC
- ~114 simultaneously running processes
- Backplane: 1Gbps
- Capacity: 3MSAU

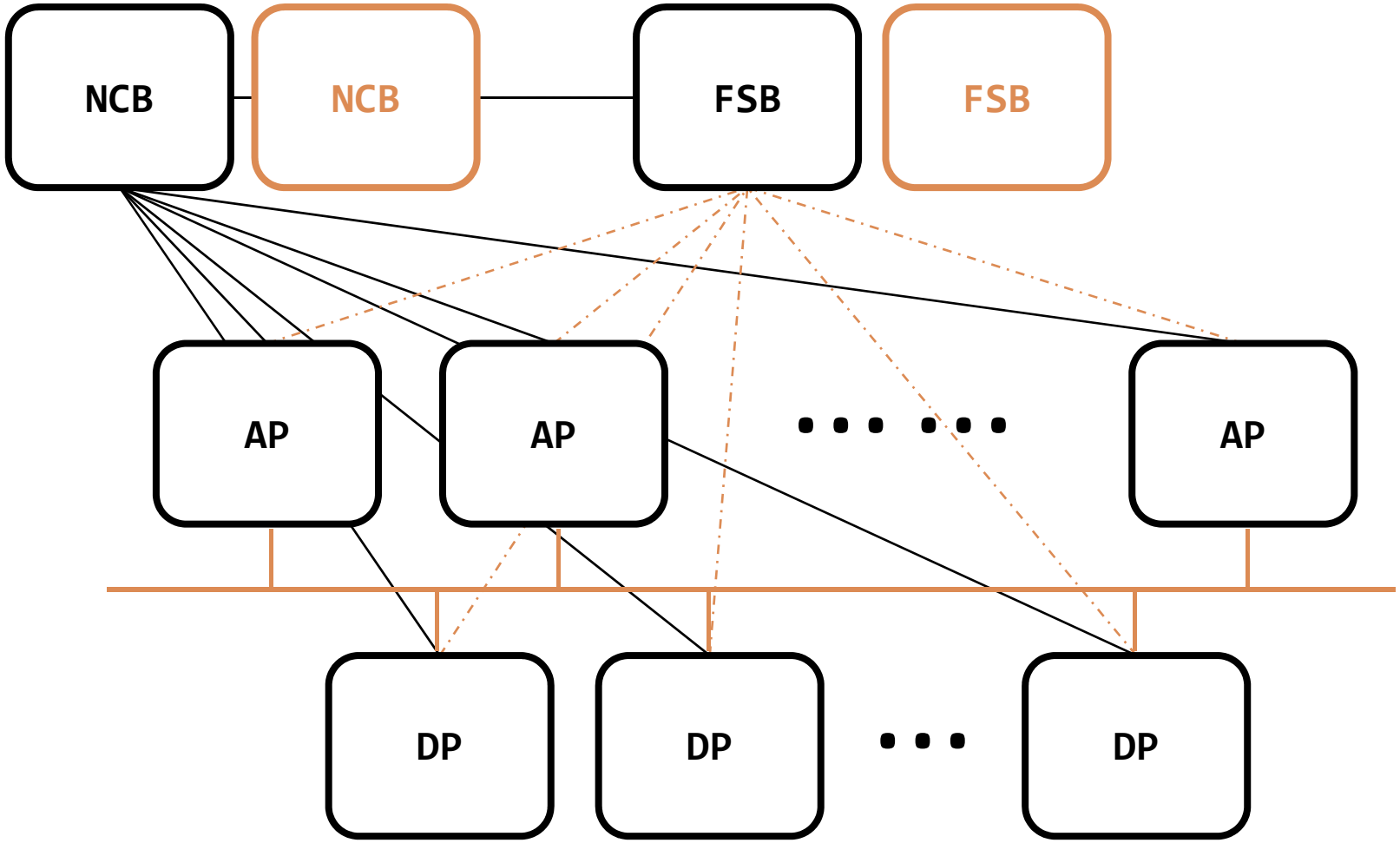
SGSN-MME MkVIII

- 3 sub-racks
- 14 blades (4+12)
- 6 core SMT Intel x86
- ~432 simultaneously running processes
- Backplane: 1Gbps
- Capacity: 18MSAU

SGSN-MME MkX

- 3 sub-racks
- 14 blades (2+12)
- 10 core SMT Intel x86
- ~720 simultaneously running processes
- Backplane: 10Gbps
- Capacity: 36MSAU

SGSN-MME - Architecture Sketch



SGSN-MME - Use The Right Tool

- Control Plane
  - Erlang
    - concurrency
    - distribution
    - fault-tolerance
  - DSL: frameworks for protocol implementation
- User Plane
  - C: time-critical packet forwarding

The Functional Advantage

- Protocol Programming
  - 3GPP standards
  - Domain experts not software engineers
- DSL
  - A “library” of abstractions
    - Possible in any language
    - Often easier in a functional language
  - A set of combinator “glues”
    - Considerably more powerful in a functional language

Typical Concurrency Patterns

- One mobile – one process (replicated worker)
  - Isolation
  - Synchronisation only with resources
- Central resources
  - Resource allocator
  - Master/coordinator – slave/worker
  - Transaction handler

Distribution

- One mobile – one process
  - Evenly distribute all phones over all blades
  - Replicate data for fault-tolerance
- Central resources
  - Run on the master-blade
  - Replicate to all the slaves
  - Can we survive without a master?

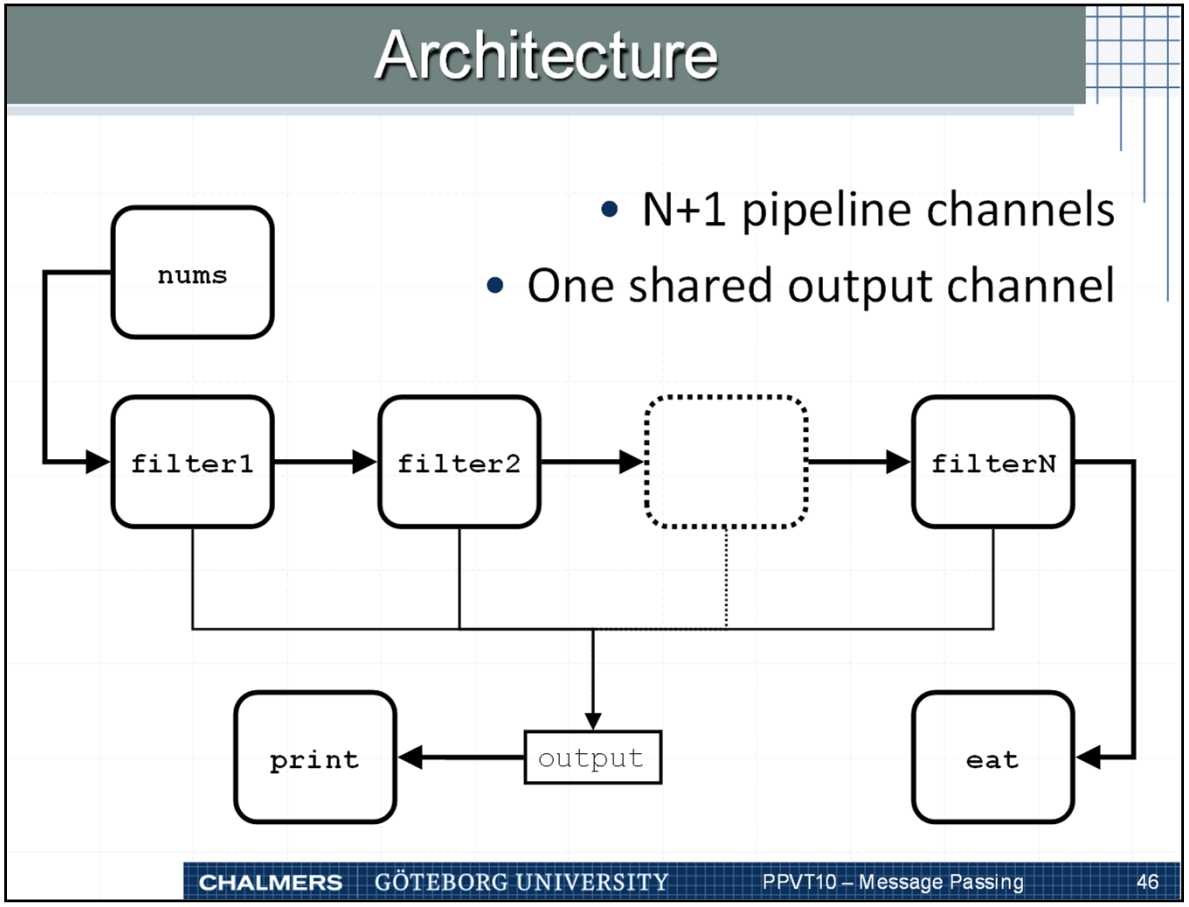
Fault-tolerance

- SGSN-MME requirement: 99.999% availability
- Hardware
  - Faulty blades are automatically taken out of service
  - Mobile phones redistributed
- Software
  - Fail fast – offensive programming
  - Recovery strategy

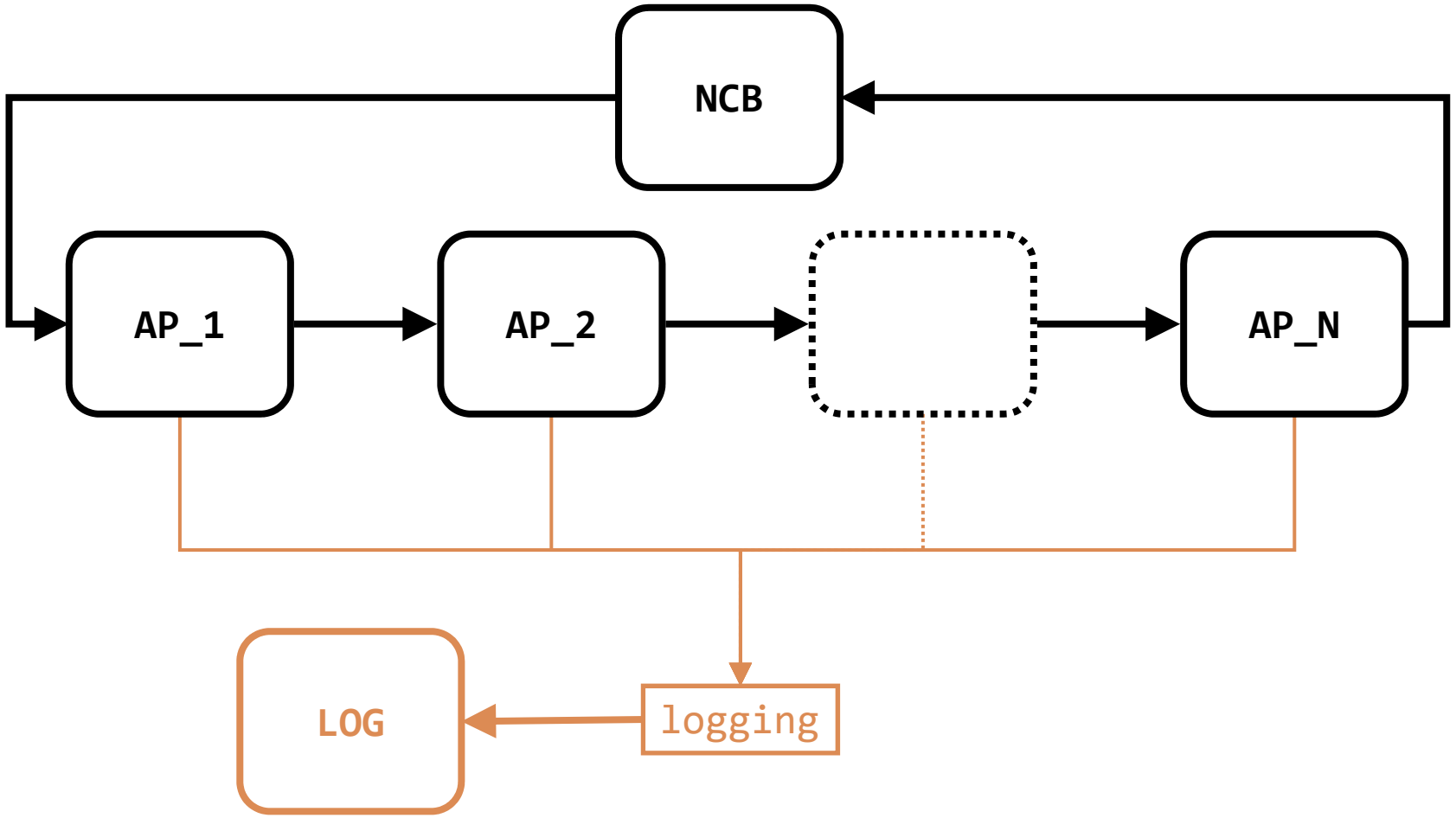
Fault-tolerance - Software

- Phone process crash should never affect others
  - Automatic memory handling
  - Process monitoring
- Recovery Strategy – escalate
  - Restart the phone process
  - Restart the whole blade
  - Restart the whole node

Sieve of Eratosthenes



Pipeline of Processes



Haskell Patterns - Monads

- Good
  - Keeps pure and side-effecting computations apart
    - Good separation of concerns
    - Improved compositionality
    - Possible performance gain
  - Gather writes together and write to DB once – amortise the cost of transactions:
    - 1 item write costs 10
    - 10 items write is not 100 but only 20!

Haskell Patterns - Monads

- Bad
  - In rapid prototyping it can present a big hurdle to jump over
  - So, it is good that Erlang does not have static types
  - Lazy evaluation is more complicated in the presence of side-effects especially inter-process communication

OO-Design Patterns

- Factory method
  - Improve memory sharing
- Object pool
  - Bounded parallelisation of algorithms – thread pool
  - Overload protection

What they do not teach you

- Software lives long
  - Especially telecom systems (decades)
  - Banking systems live even longer (think Cobol)
- People change
- Organisations change
- Hardware changes
- Requirements change
- Documentation often does not change

Software Maintenance

- The developer's challenge
  - Write simple (readable) and efficient code:
    1. Write a straightforward and working solution first
    2. Optimise later (or even better skip this step)
- Think smart but do not over-optimise
  - Optimisations complicate maintenance
- The code is often the only reliable document
  - Types can be very good documentation

Synthesis and Analysis

- Emphasis on synthesis in education
  - Software development from scratch
- Industrial systems often have a legacy
  - Software development by further iteration
    - Refactoring
    - Code review
    - Software maintenance
  - Need for both analytical and synthesizing thinking

Synthesis and Analysis

- Roughly 30% of manpower is spent on testing
  - Analytical work
  - Do you like to break a system?
- But testing can also be “synthesizing”
  - Testing frameworks
    - QuickCheck
    - SGSN-MME has its own
  - Formally prove the system correctness?

Erlang in Practice – Pros

- Well suited for
  - Control handling of telecom traffic
  - Application layer (OSI model) applications
    - Web servers, etc.
  - Domain Specific Language – framework
    - Test scripting
- Reasonably high-level (compared to C)
  - Good for software maintenance

Erlang in Practice – Pros

- Dynamic typing
  - Aids rapid prototyping
- OTP – includes useful building blocks
  - Supervisor
  - Generic server
  - Finite state machine

Erlang in Practice – Cons

- Hard to find good Erlang programmers (?)
  - Management b.....t
  - Long live Chalmers
- A bit too low-level language
  - Given current HW limitations one must sometimes optimise to the point where the code is not portable (with the same performance)
  - Raise the abstraction and provide a customisable compiler, VM (Elixir?)

Erlang in Practice - Cons

- Where is the type system?
  - A static type system of Haskell-nature would probably be a hindrance
  - But good static analysis tools are desperately needed
  - Types are an excellent form of documentation

More Than True

Sayings

- The greatest performance improvement of all is when a system goes from not-working to working
- The only thing worse than a problem that happens all the time is a problem that doesn't happen all the time

Functional Programming

- Widespread use
  - Embedded (cars, satellites, etc.), web-apps, games, banks, big-data, …
- Abstractions and compositionality
- Productivity gains

The Industrial Experience

- It is more difficult that you expect, but
  - Usually not in complexity but size
- Good methodical approach helps
- Lateral thinking is an asset
  - Learn many programming paradigms
  - Learn many programming languages