Functional Programming^{XP}

The Industrial Experience

Dfind
IT

Karol Ostrovský

- M.Sc. – Comenius University, Bratislava
- Ph.D. – Chalmers
- Post-doc – Chalmers
- System Designer – Dfind IT
  - **On assignment for Ericsson**
  - **Operations & Maintenance Subsystem**

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

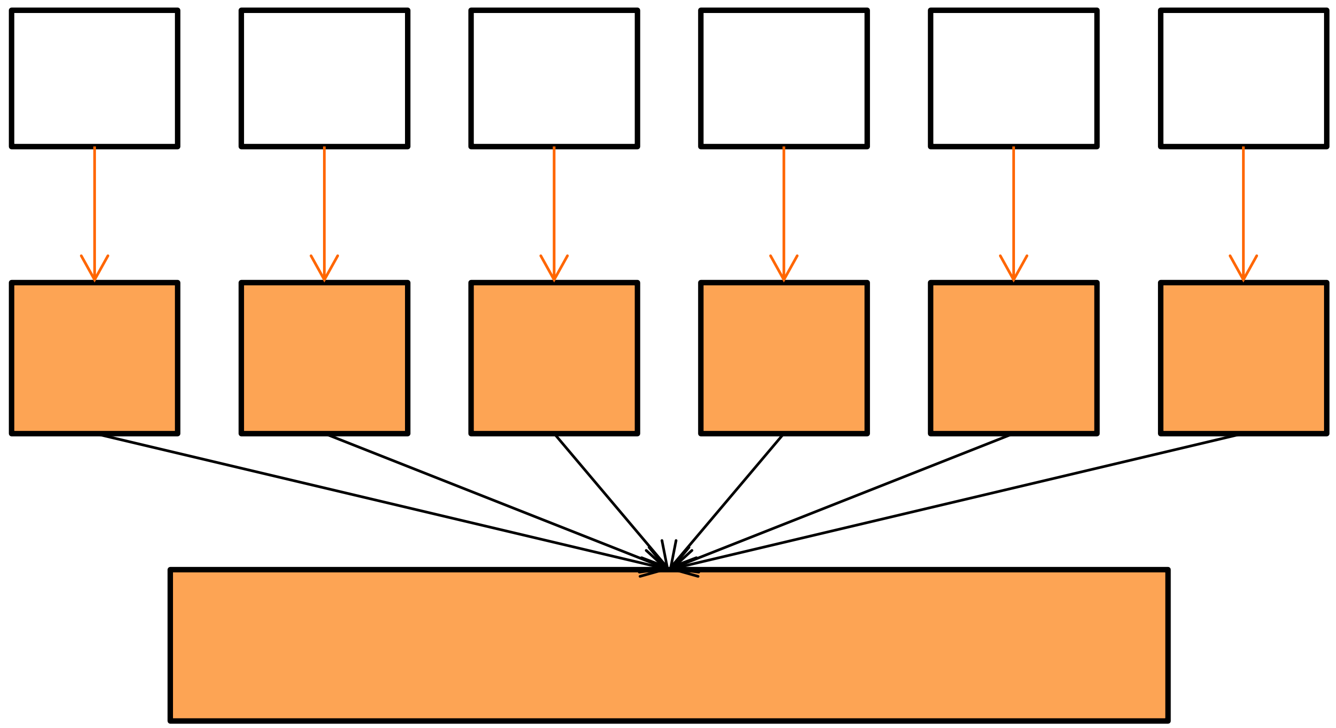
The Language & Paradigm Nerd

- Language skills
  - Basic
  - Pascal
  - C/C++
  - Scheme
  - SmallTalk
  - Java
  - JR (MPD)
  - Haskell
  - Erlang
  - Ocaml
  - LaTeX
  - VAX assembler
  - Trilogy
  - Ada
  - Agda
  - Some of my own

Dfind IT

What is Programming?

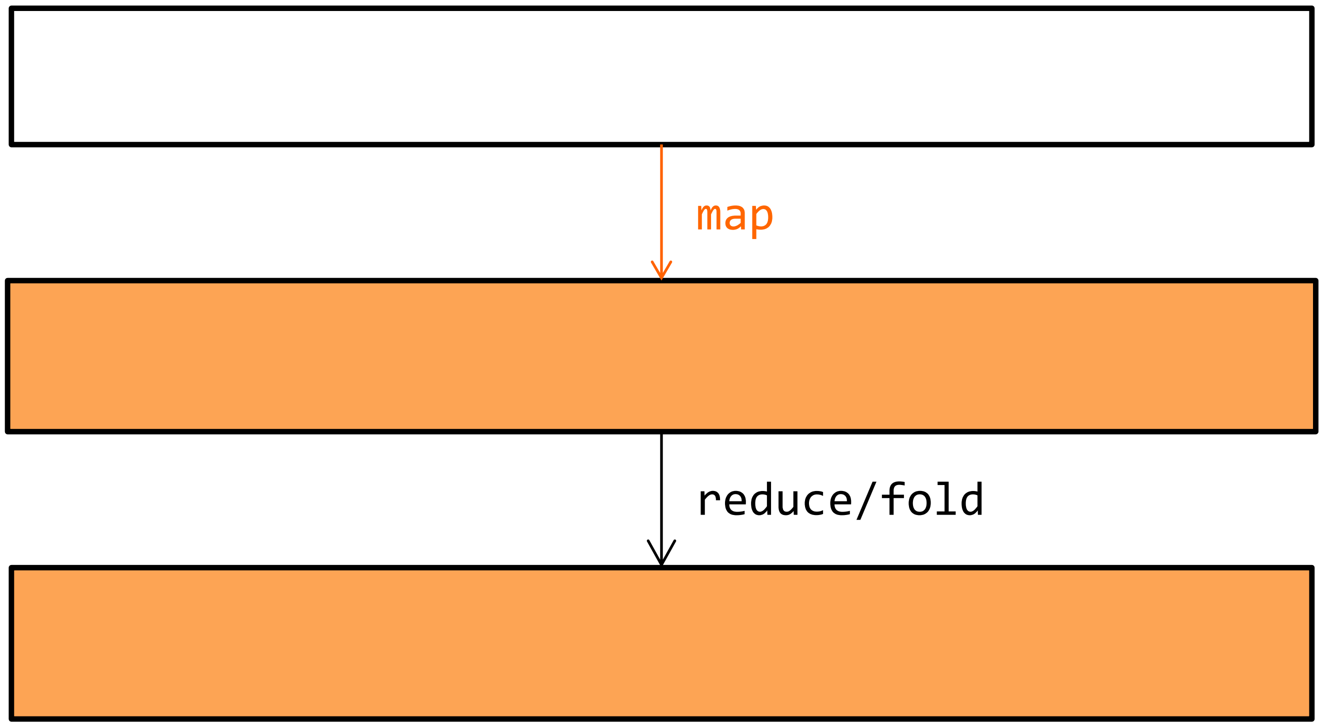
- Manipulation of Structures



Dfind IT

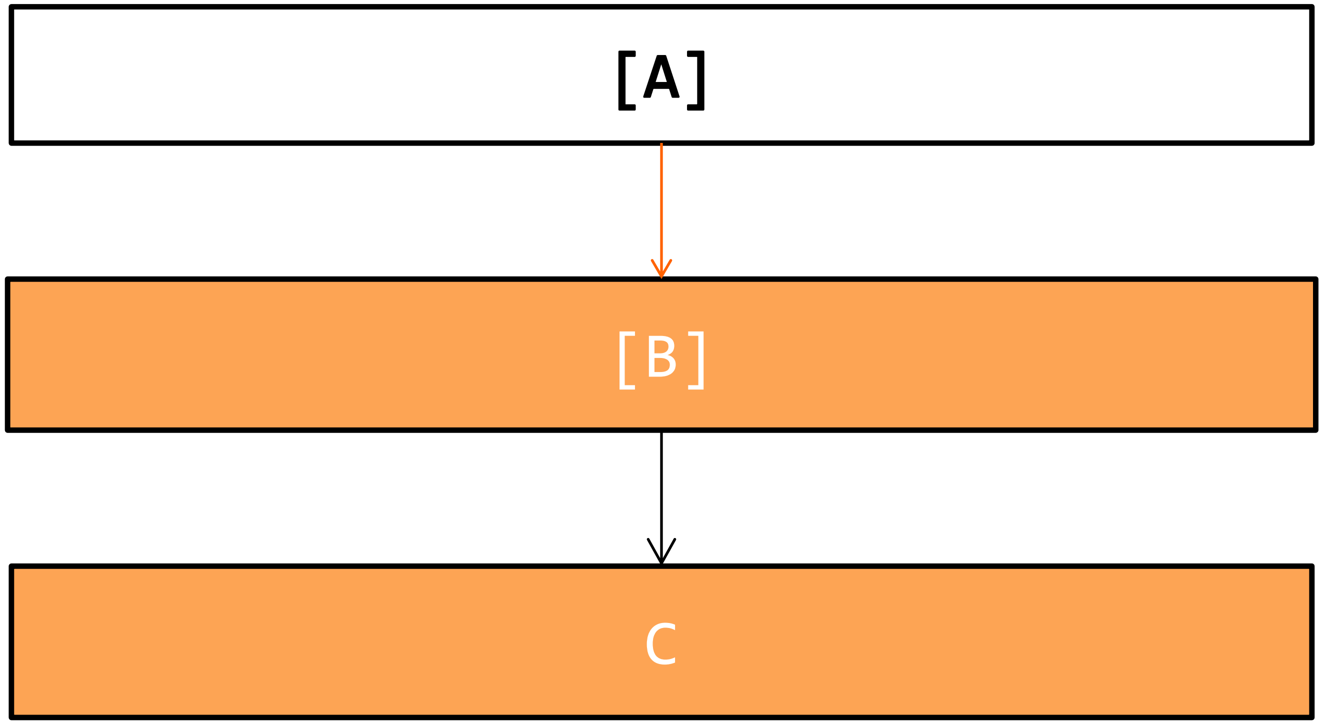
Compositions

- Functions



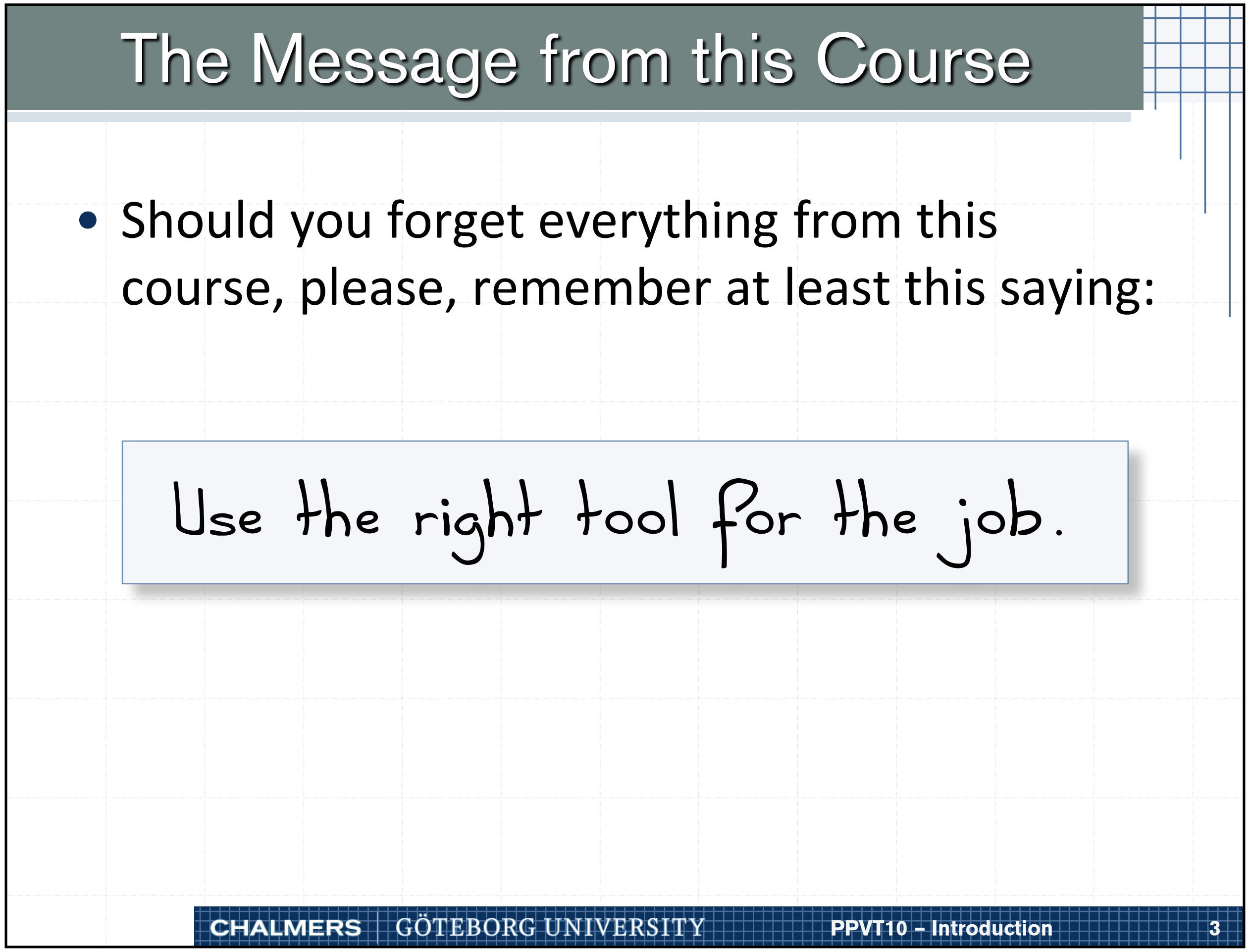
Structures

- Types



Dfind IT

My Favourite Slide



The Message from this Course

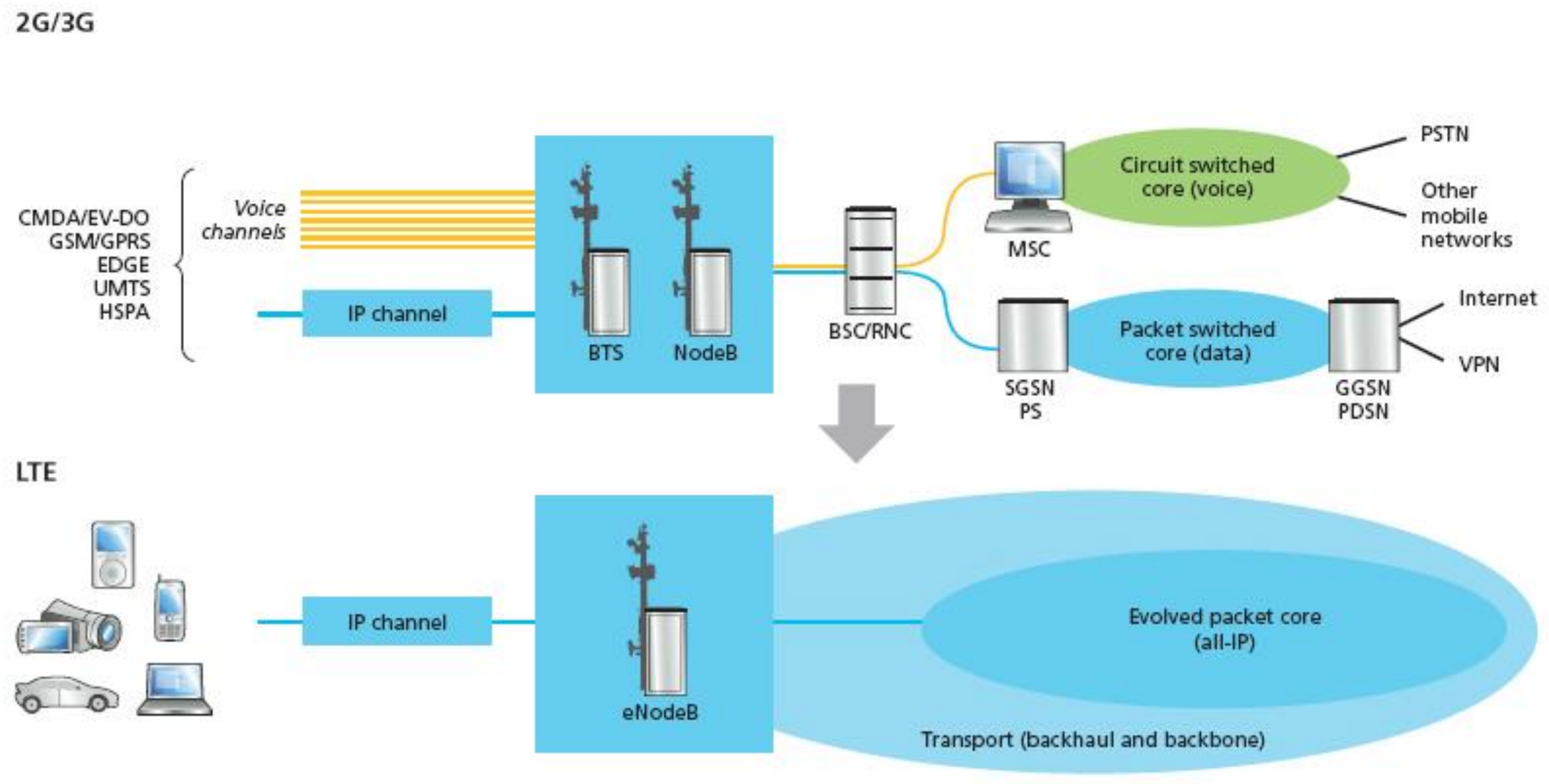
- Should you forget everything from this course, please, remember at least this saying:

Use the right tool for the job.

CHALMERS | GÖTEBORG UNIVERSITY PPVT10 – Introduction 3

Dfind IT

Mobile Telecom Network



Dfind IT

Packet Core Network

- 3GPP
  - Defines standards (mostly protocols)
  - Interoperability is essential
- SGSN-MME
  - Servicing GPRS Support Node (2G/3G)
  - Mobility Management Entity (4G)
  - Control signalling
    - Admission control, Authentication
    - Mobility, roaming
  - Payload transport (not in 4G)

SGSN-MME MkVI

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

Dfind IT

SGSN-MME MkVIII

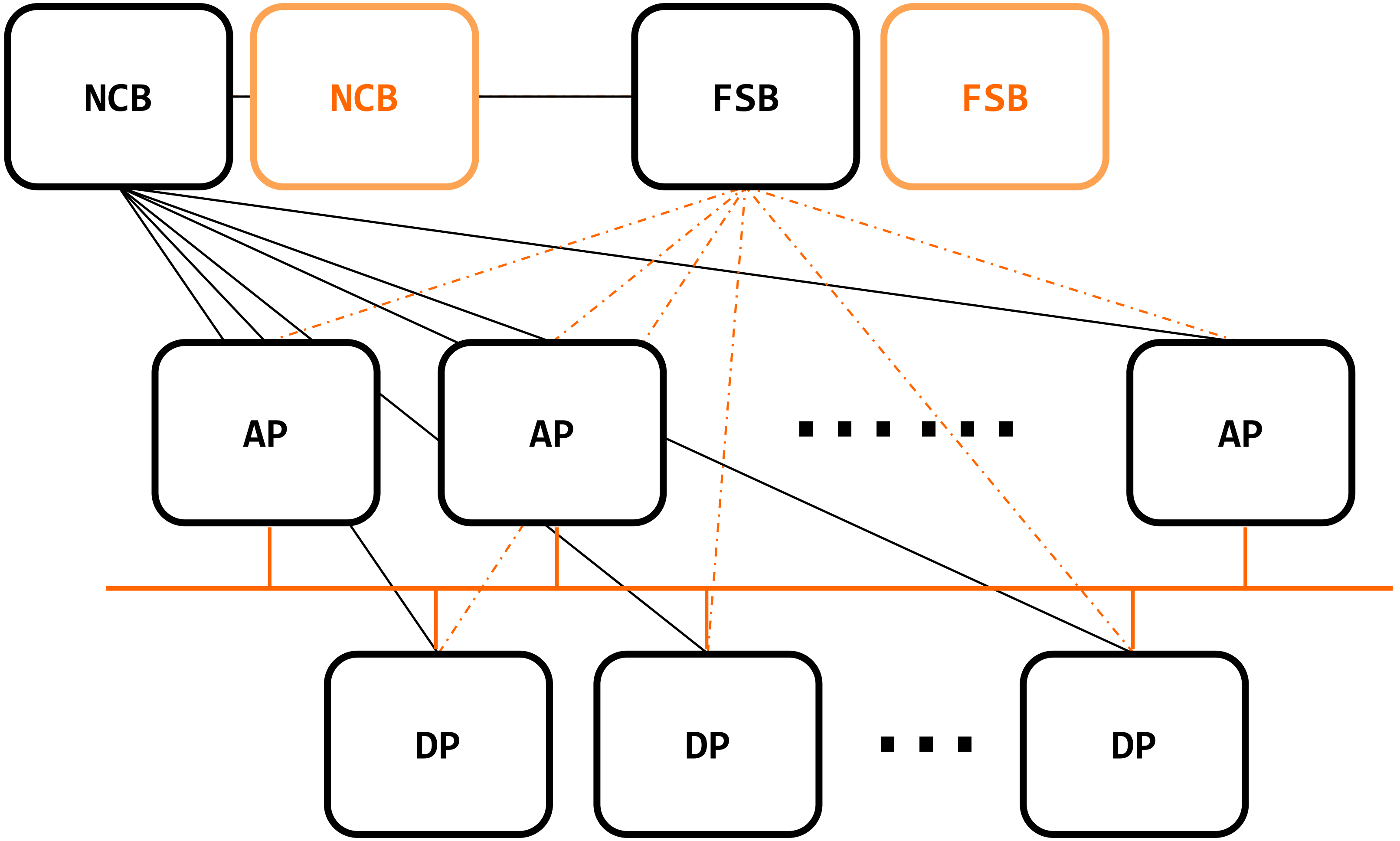
- 3 sub-racks
- 14 blades (2+12)
- 6 core Intel x86
  - **12 SMT threads total**
- *~ 432 simultaneously running processes*

- Backplane: 1 or 10Gbps

- Capacity: 10MSAU

Dfind IT

SGSN-MME – Architecture Sketch



Dfind IT

SGSN-MME – Use The Right Tool

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

Erlang – 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**

Dfind IT

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

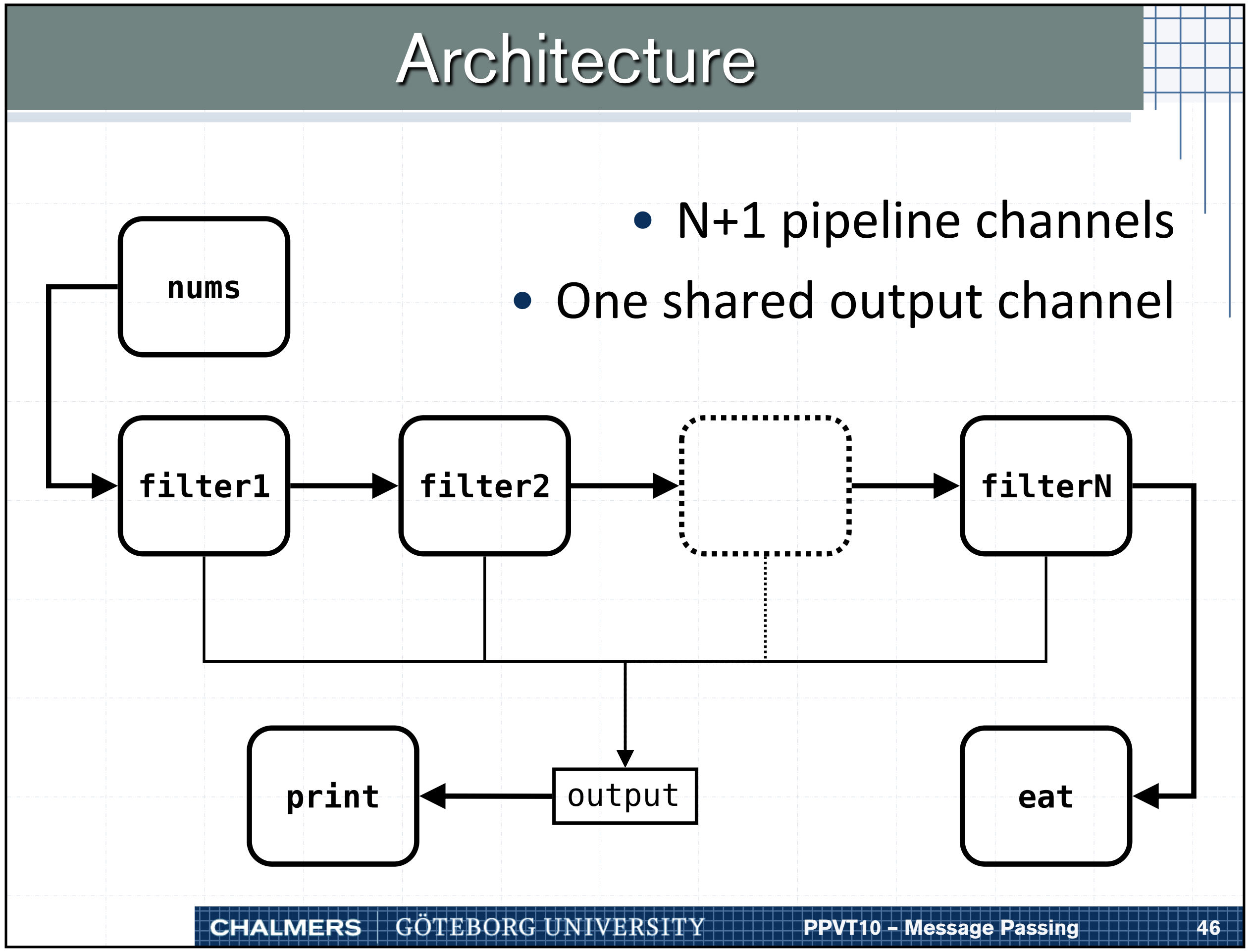
- Hardware
  - **Faulty blades are automatically taken out of service**
  - **Mobile phones redistributed**
- Software
  - **Fail fast – offensive programming**
  - **Recovery strategy**

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

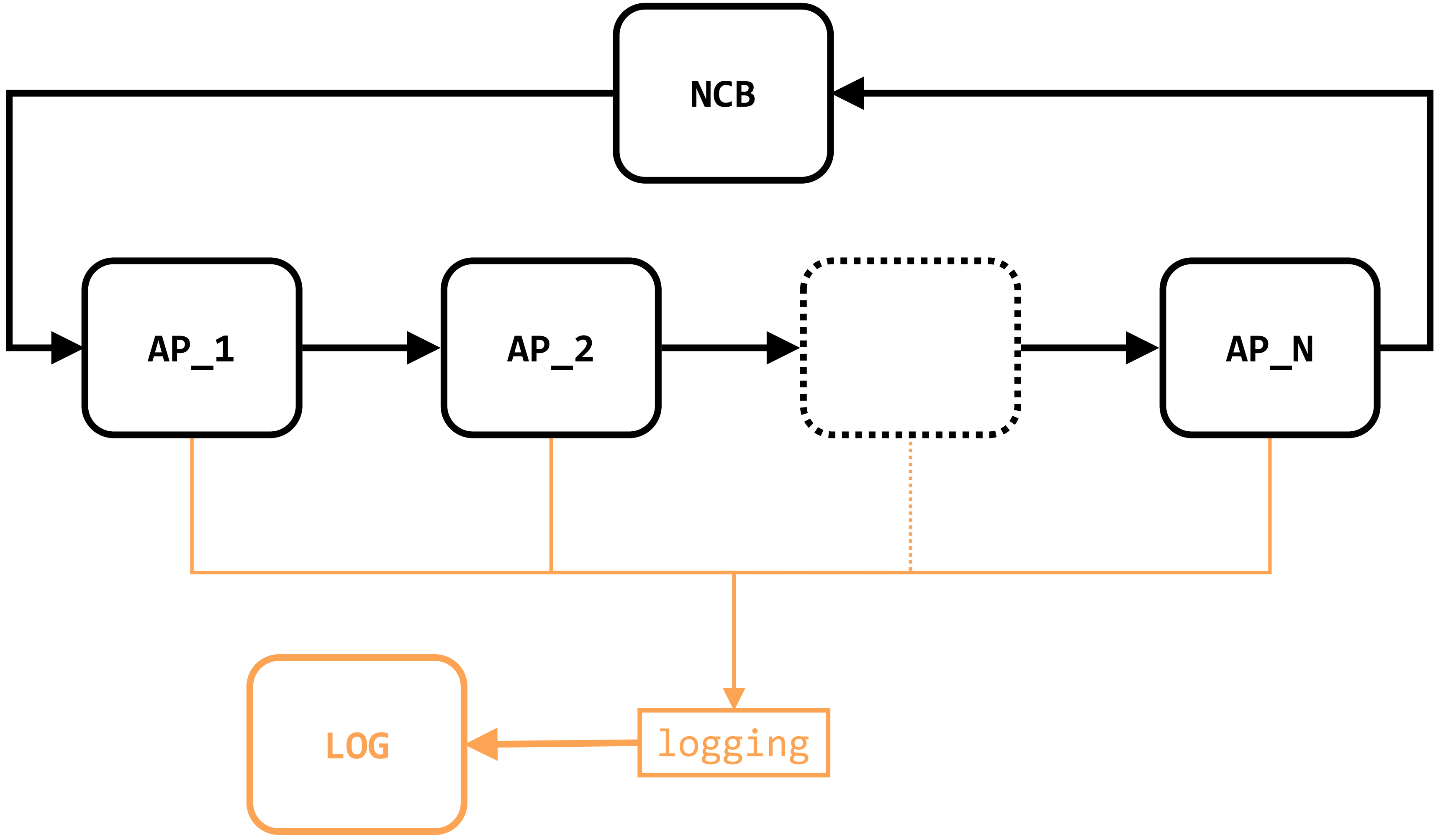


Architecture

- N+1 pipeline channels
- One shared output channel

CHALMERS | GÖTEBORG UNIVERSITY PPVT10 – Message Passing 46

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**

Dfind IT

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**
  - **Would you like to formally prove the system correct?**

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 (as compared to for example 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

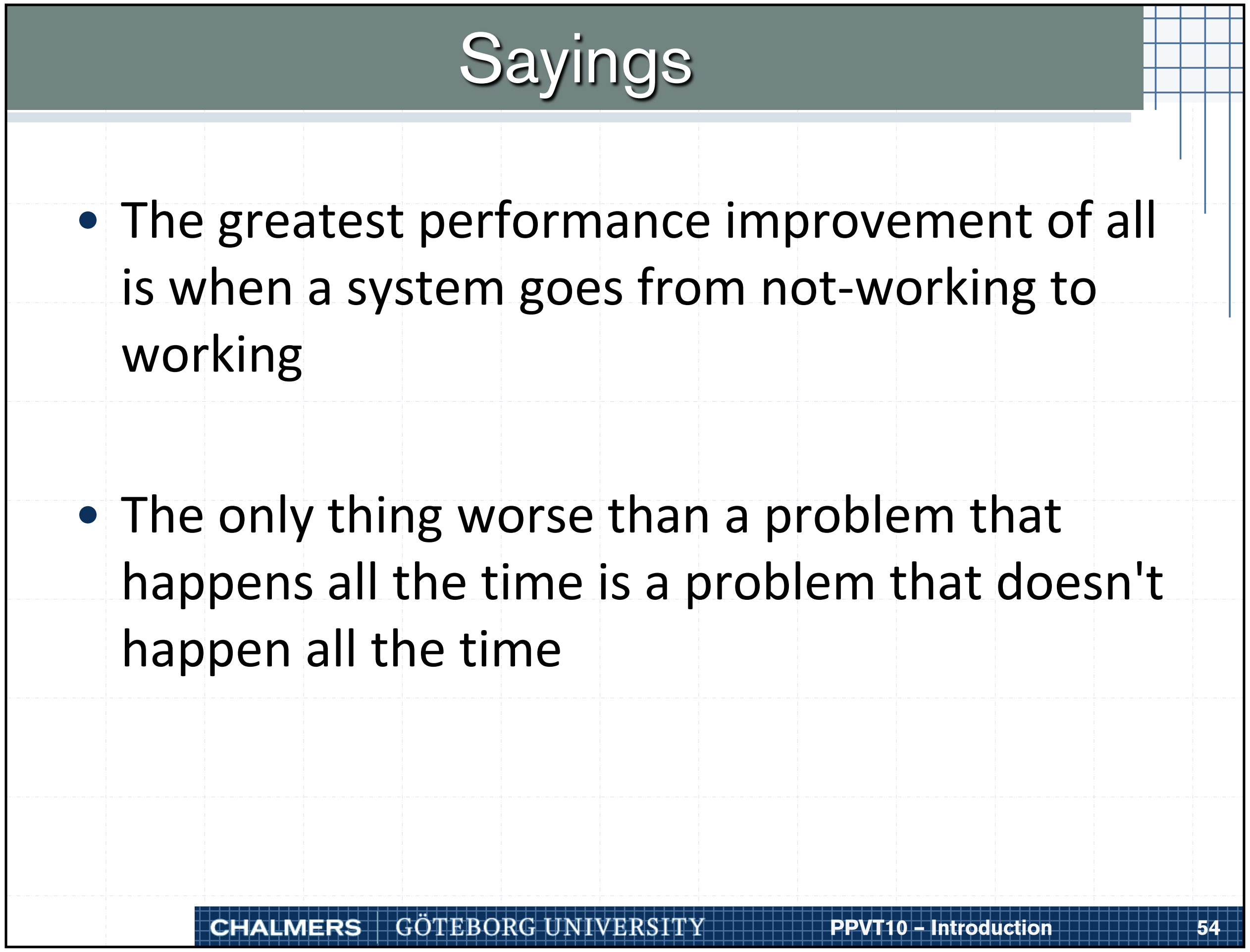
- Hard to find good Erlang programmers (?)
  - **Management b......t**
  - **Long live Chalmers**

- 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

CHALMERS | GÖTEBORG UNIVERSITY PPVT10 – Introduction 54

Dfind IT

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**