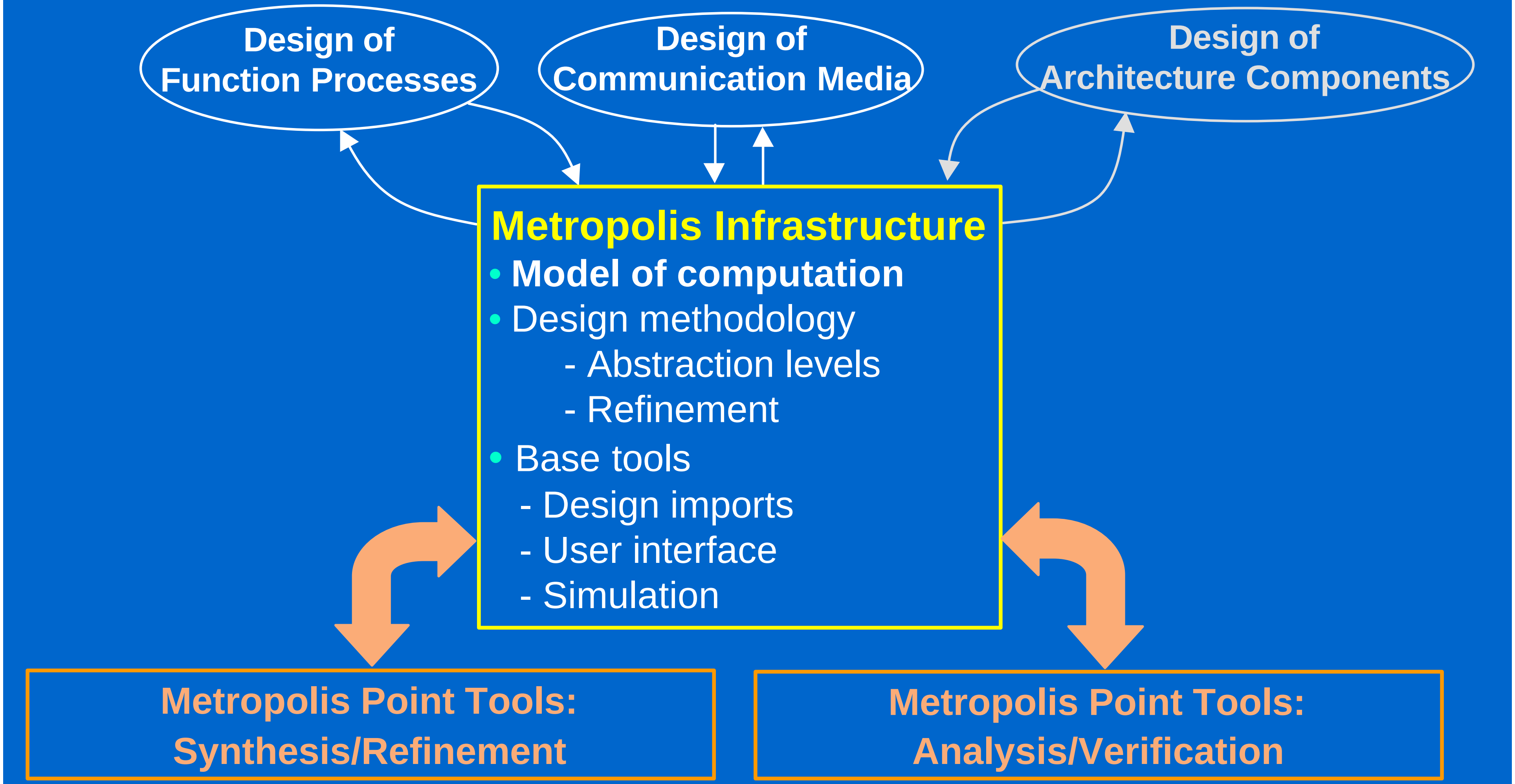
Metropolis

Metropolis Project Team

University of California Berkeley

Cadence Berkeley Laboratories

Metropolis Framework



Design of
Function Processes

Design of
Communication Media

Design of
Architecture Components

Metropolis Infrastructure

- **Model of computation**
- Design methodology
  - Abstraction levels
  - Refinement
- Base tools
  - Design imports
  - User interface
  - Simulation

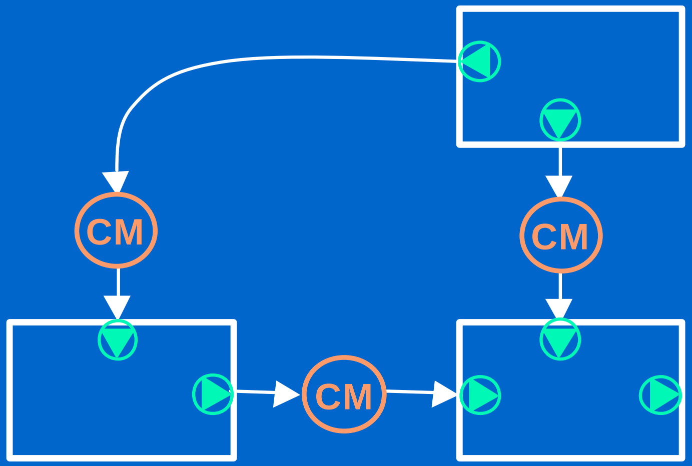
Metropolis Point Tools:
Synthesis/Refinement

Metropolis Point Tools:
Analysis/Verification

Metropolis: Model of Computation

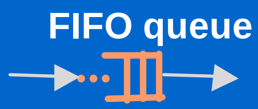
- System function: a network of processes
  - process: sequential function + ports
- Do not commit to particular communication semantics
  - ports: interconnected by communication media
  - communication media: define communication semantics

    e.g. queues, shared memory, … , generic, ...
- Do not commit to particular firing rules of processes
  - a special construct to define interaction between processes and media



Communication

- **Communication medium:**
  - **state**: snapshot of the medium
  - **interfaces**: read, write, status-check, ...
  - **properties**: # of writers, transaction, arbitration, ...



State: # of elements, type, values, ...

Interfaces:

reader{ read(), num() }
writer{ write(), num() }
...

Properties: 1 writer, 1 reader, ...

- An interface may be supported by more than one media.
- Interface functions at different abstraction levels to support refinement.

- Language to define communication media
- Library of pre-defined media

Communication Media

```
interface reader {
      void read(data, rate);
      int num();   // # of elements
}
```

```
interface writer {
      void write(data, rate);
      int num();
}
```

```
medium bfifo reader writer {     // bounded FIFO
      int num;       // # of elements
      int depth;     // the depth of the fifo
      …
```

states

```
      int num() {
            return num;
      }
      void read(data, rate) {
            ...
      }
      void write(data, rate) {
            …
      }
```

interface functions

Process

- **Ports:**
  - **Each port is specified with an interface it can access to.**

    All and only the functions of the interface can be used through the port.

- **Sequential program:**
  - **Interaction with communication media**

    await(cond){ st1; st2; … stk;}

    “if cond is TRUE, then atomically execute {st1; … stk;}.”

    - **Atomic operations**
    - **Micro steps**
  - **Non determinism**
  - **Bounded loops**
  - **Parameters**

Process

```
interface reader {
    void read(data, rate);
    int num();
}
```

```
interface writer {
    void write(data, rate);
    int num();
}
```

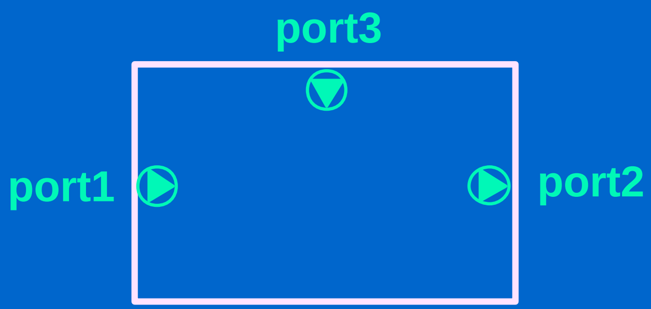
```
process filter {
    reader port1;
    writer port2;

    await(port1.num() > 7) {
            port1.read(V, 8);
    }

    bounded_loop(i, 0, 4, 1){    //  for(i=0; i<4; i=i+1)
            V[ i ]  =  V[ 7 - i ];
    }

    …
}
```

port1
port2

Process

```
interface reader {
      void read(data, rate);
      int num();
}

process filter {
      reader port1, port3;
      writer port2;

      c = 1;
      await(port1.num() > 7 || port3.num() > 0) {
                if(port3.num() > 0)  port1.read(c, 1);
                if(port1.num() > 7)  port1.read(V, 8);
      }

      bounded_loop(i, 0, 4, 1){
                V[ i ]  =  c * V[ 7 - i ];
      }

      …
}
```

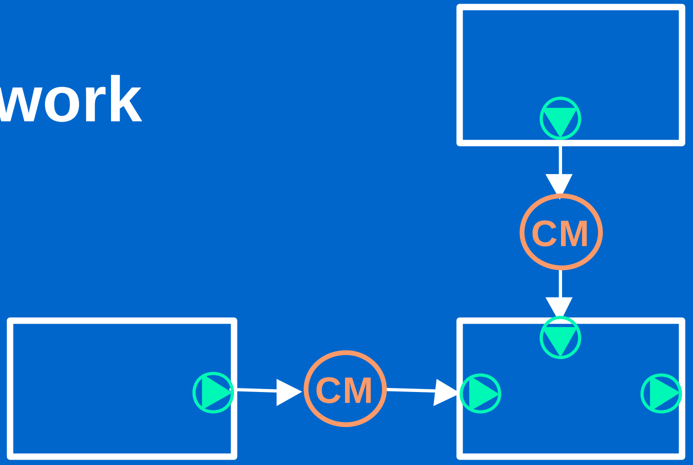
```
interface writer {
    void write(data, rate);
    int num();
}
```



Network of Processes

- **Define the structure of a network**
  - **Instantiate processes: set parameters**
  - **Instantiate communication media: set parameters**
  - **Specify connections**

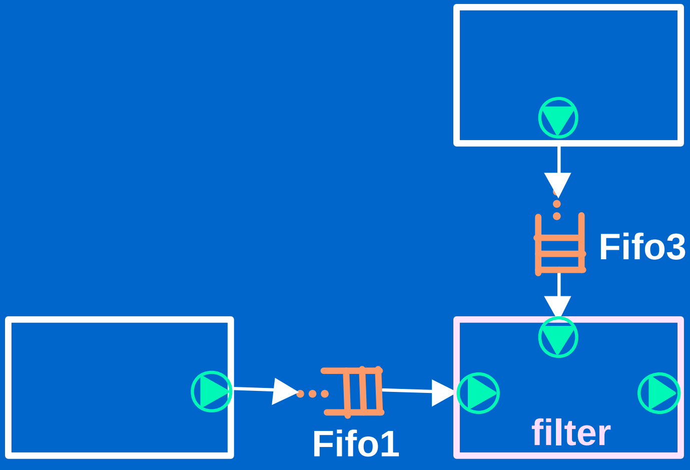
- **Specify constraints on the network**
  - **Scheduling constraints**
  -



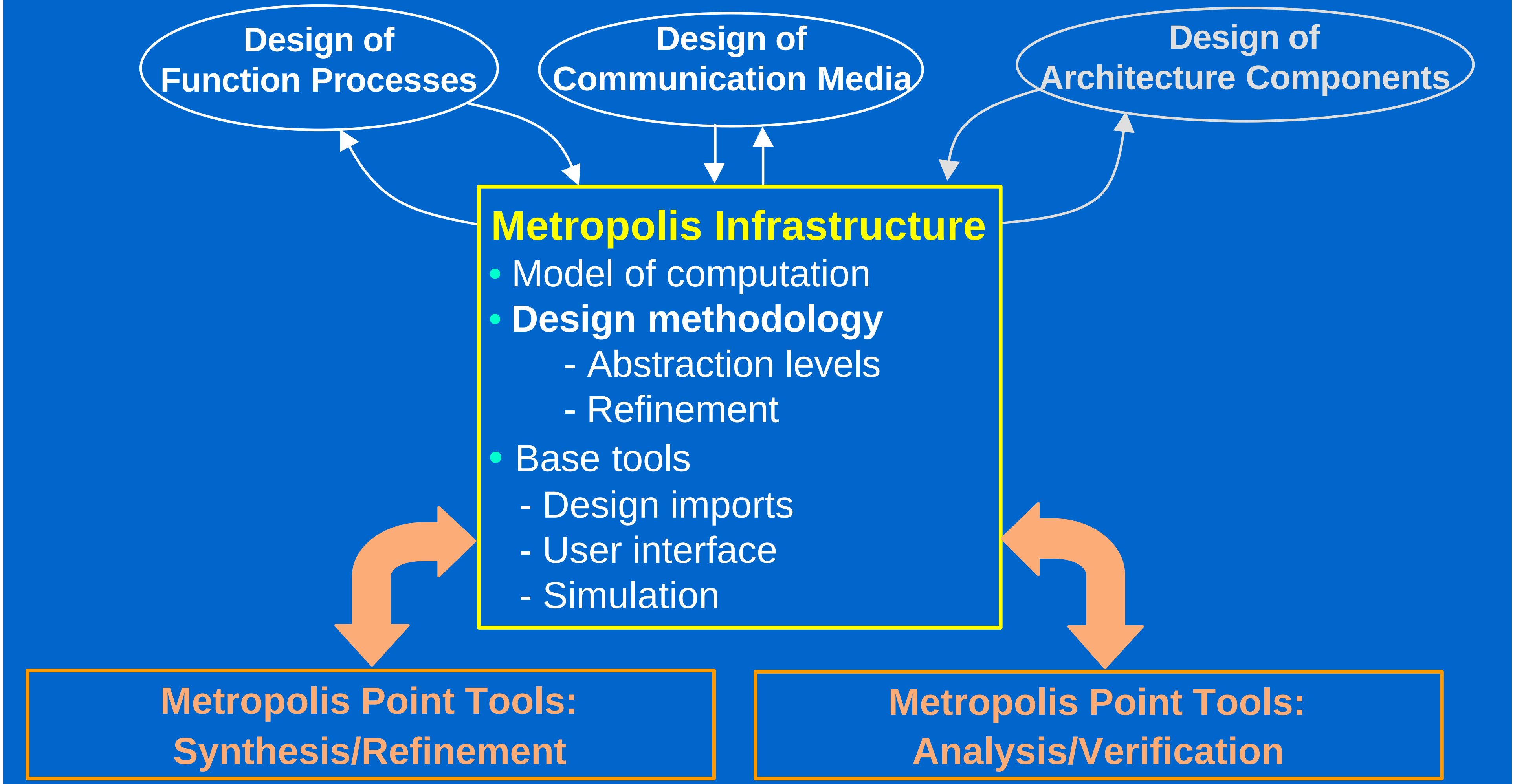
A network may be hierarchical; a process may be a subnet of processes.

Network of Processes

```
application  my_design {
    process F = new filter();
    medium Fifo1 = new bfifo(8, int);    // bfifo(depth, type)
    medium Fifo3 = new bfifo(1, int);

    connect(F.port1, Fifo1);
    connect(F.port3, Fifo3);

    process P = new producer();
    process C = new controller();

    ...
```



Metropolis Framework



Design of Function Processes

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Design of Architecture Components

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Design Methodology

Functional Decomposition

Behavior Adaptation

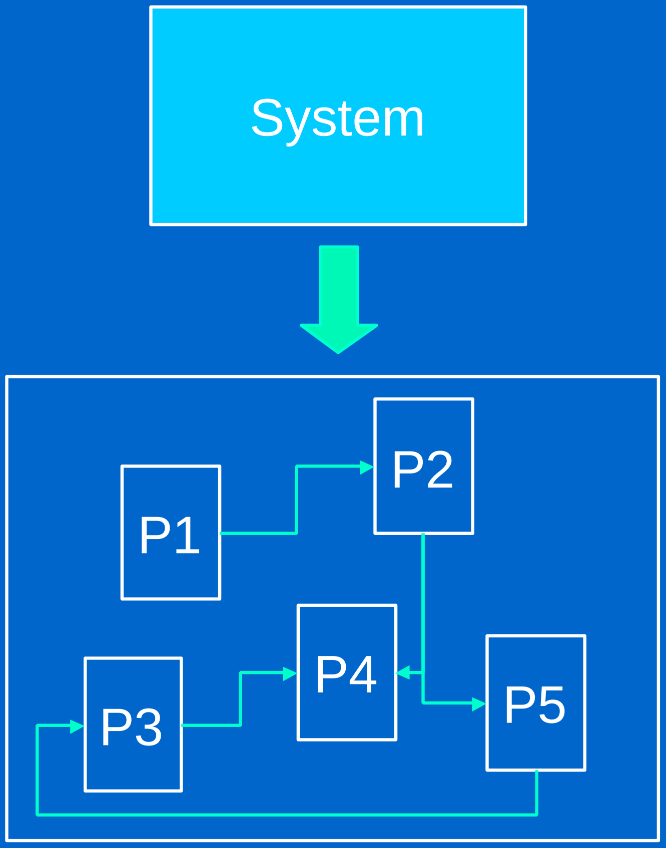
Communication Media Insertion
MoC Wrapping

Communication Refinement
Channel Adaptation

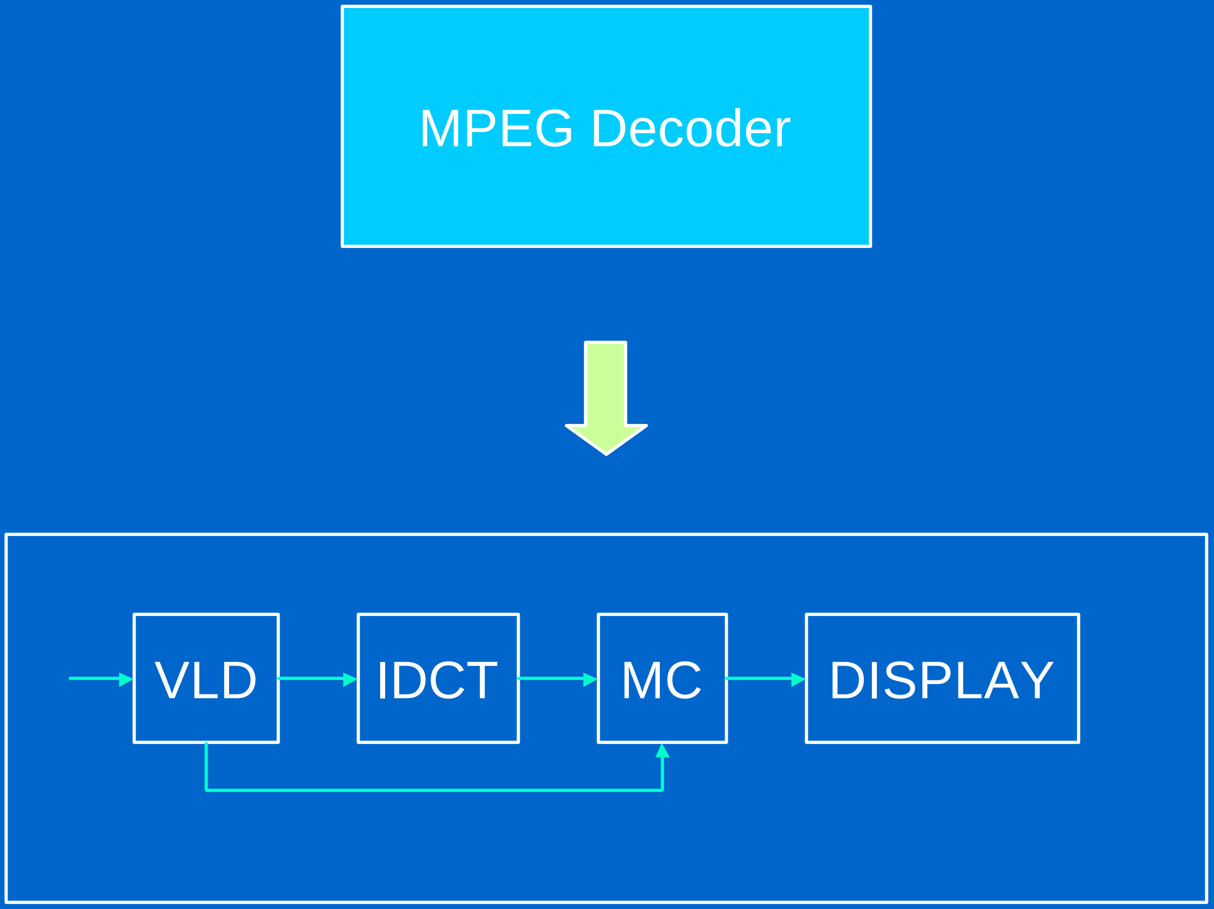
Mapping and Optimizations

Functional Decomposition

- **Functional Decomposition**
  - **at the highest abstraction level, a system is a single process**
  - **it is refined into a set of concurrent processes**
- **Process:**
  - **relation between an input domain and an output co-domain**
  - **only behavior, no communication**
  - **denotational specification**

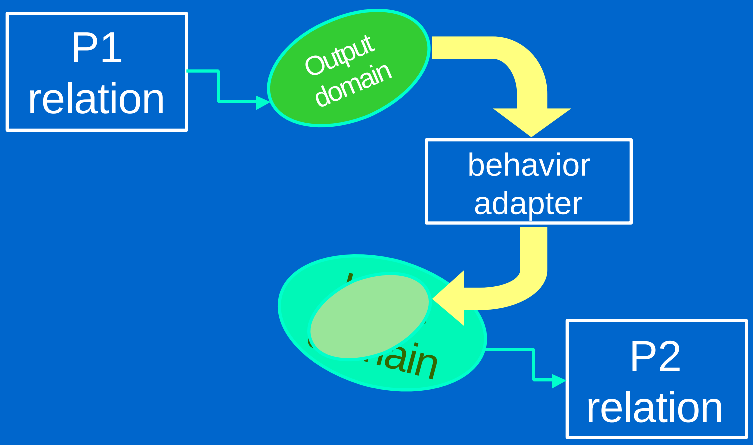


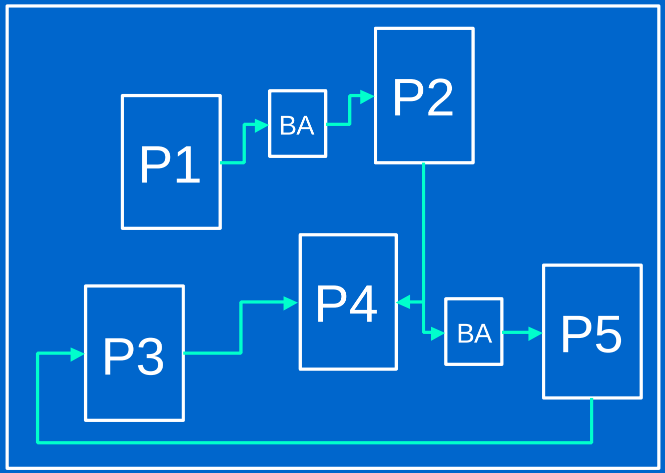
Functional Decomposition (ex.)



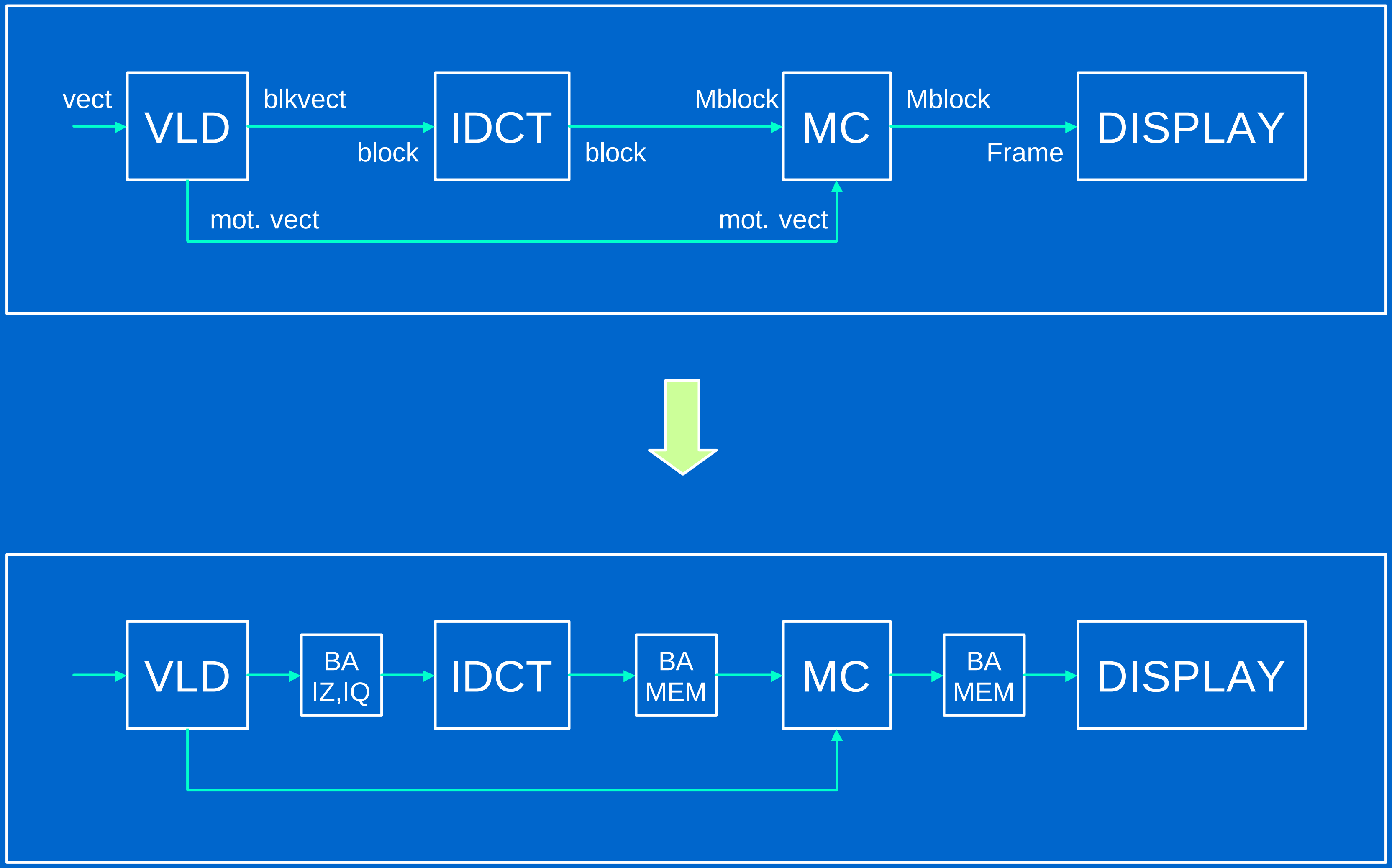
Behavior Adaptation

- **Behavior adapters**
  - **match different domains, so that processes can understand each other**
  - **relation between two domains**
  - **not part of original system specification: needed because of the particular decomposition**
  - **needed independently of how the communication is performed**



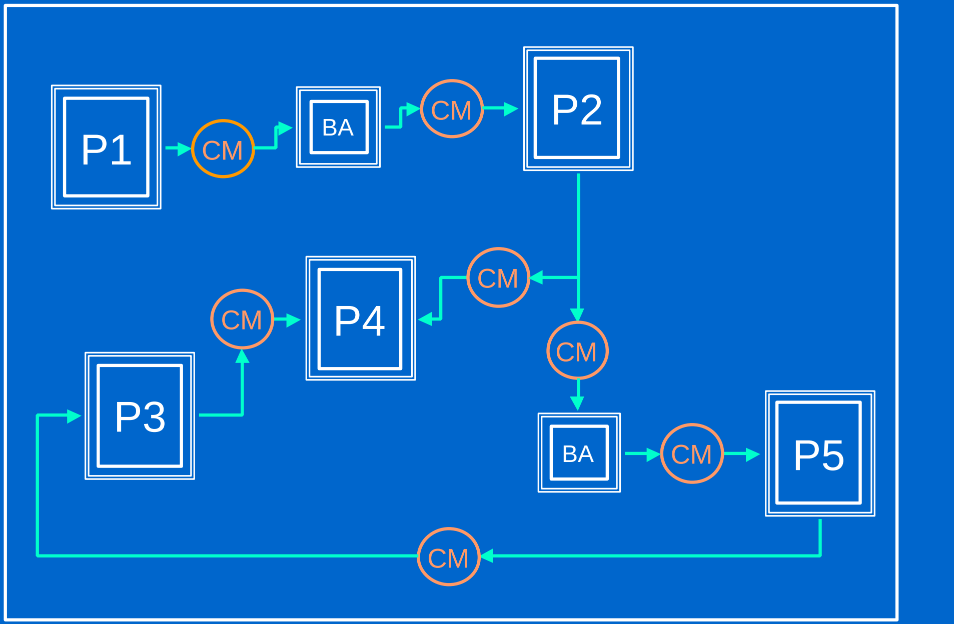


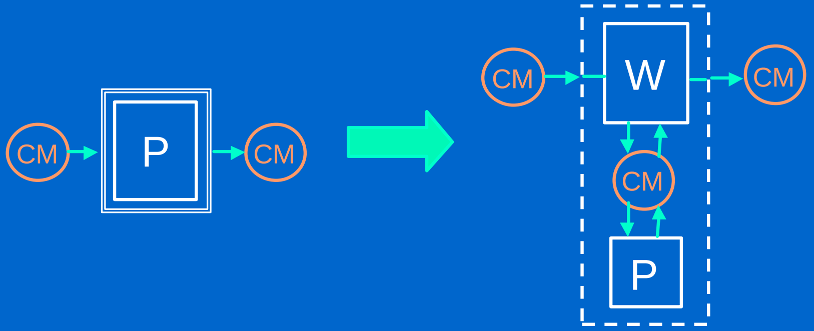
Behavior Adaptation (ex.)



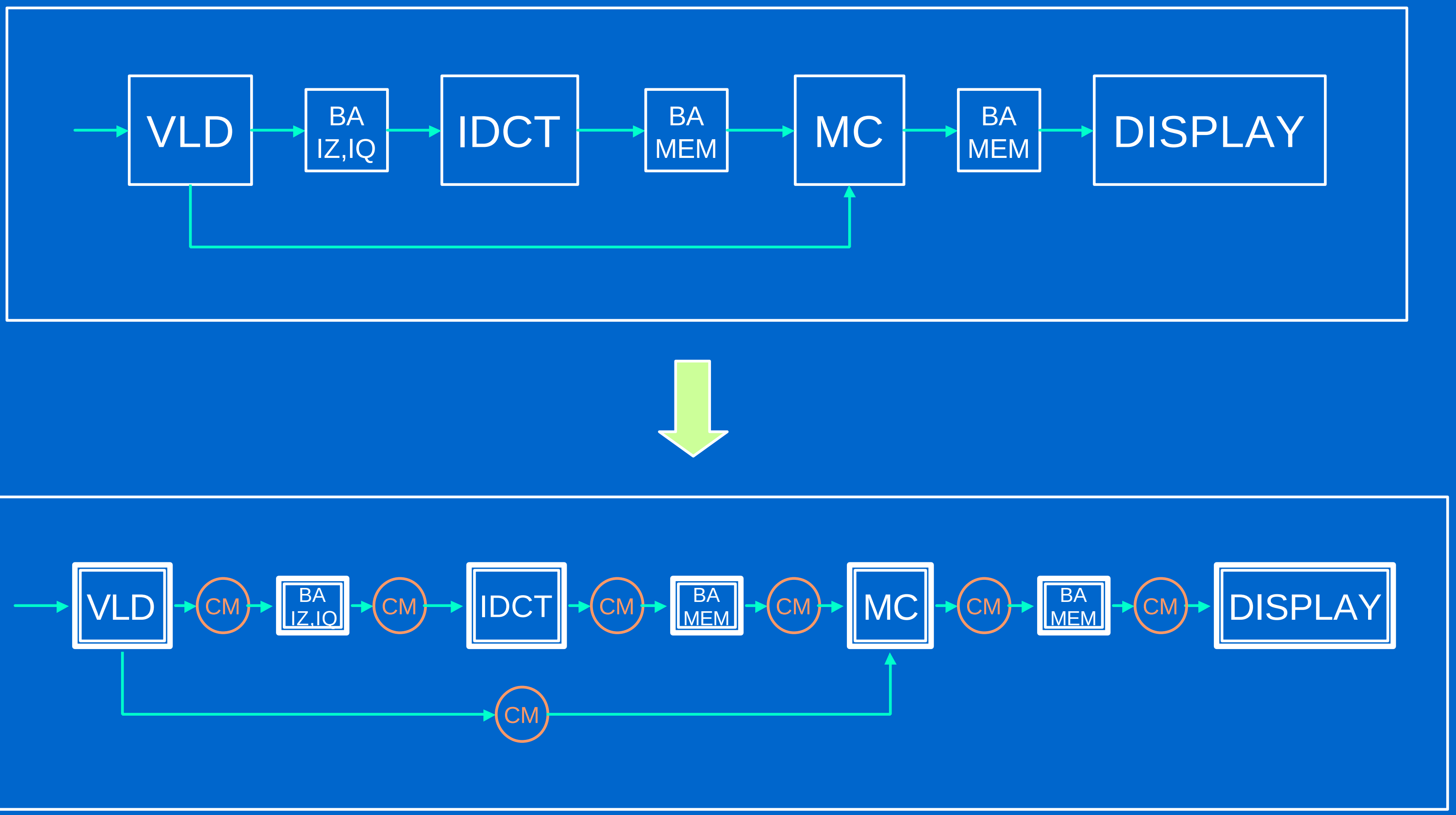
Communication and MoC

- **Communication medium**
  - **each link needs a communication medium**
  - **does not affect or change the relation inside processes**
- **MoC wrapper**
  - **used to establish a firing rule and a communication semantics for each process**
  - **only the Moc wrapper is modified if a medium is changed**





Communication and Moc (ex.)

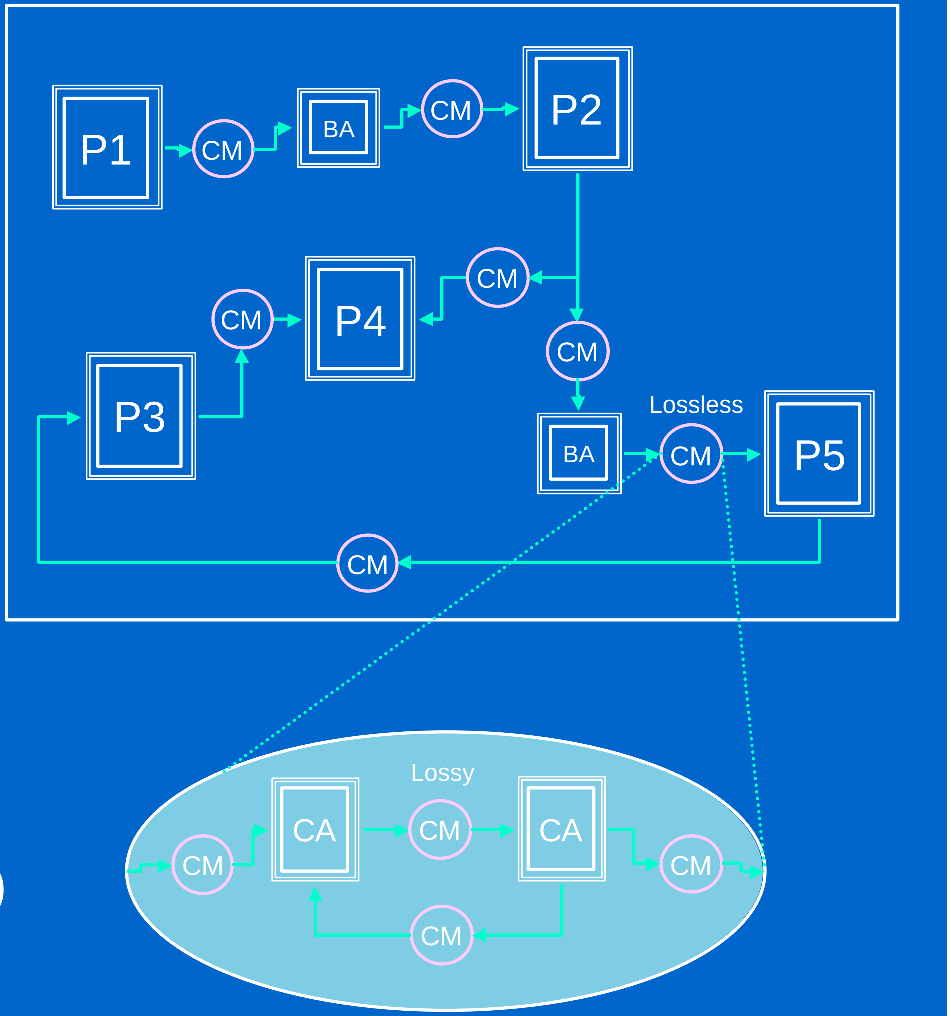


Refinement

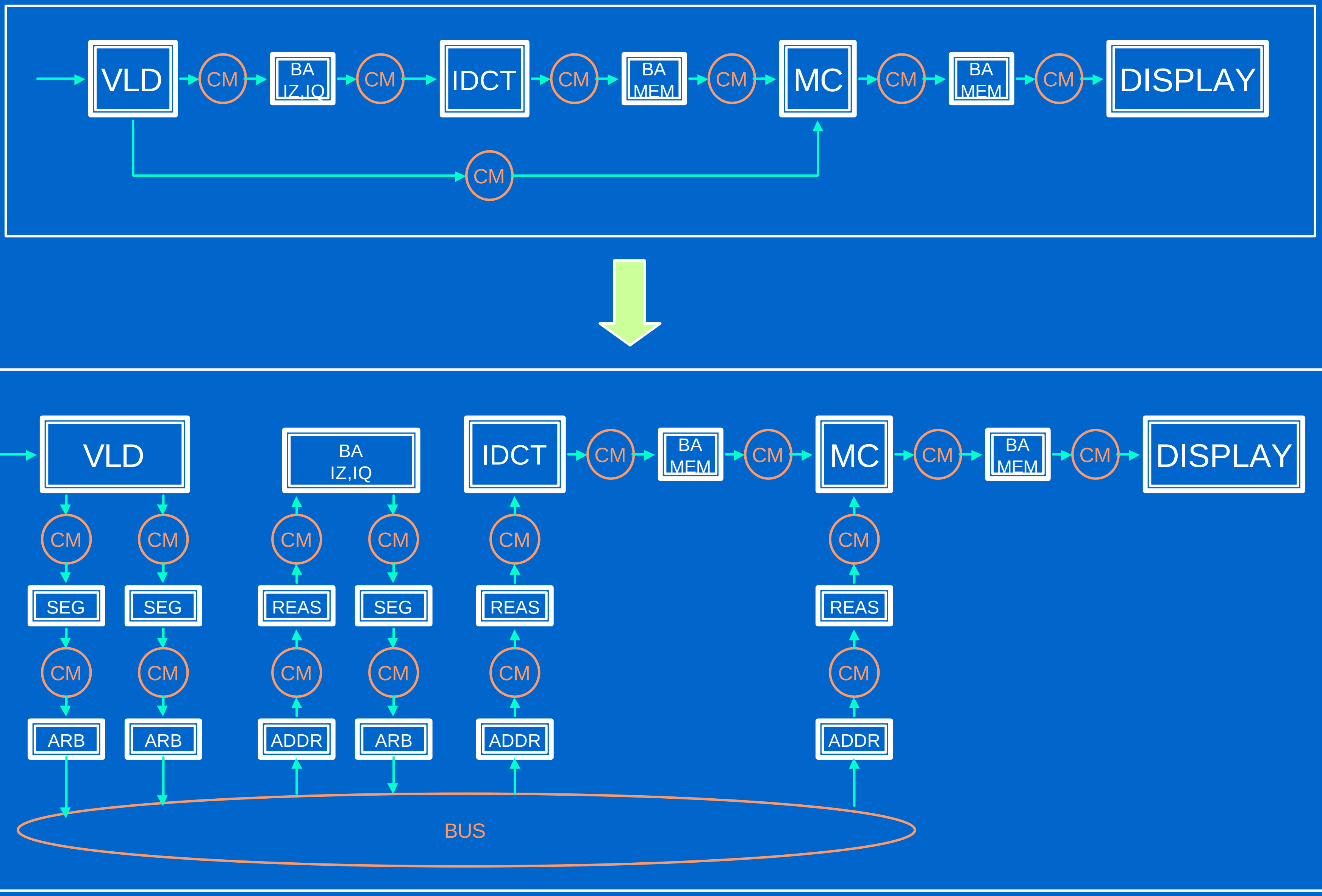
- **Refinement**
  - **any communication medium can be refined into an arbitrary netlist, as long as the interface is not changed**
- **Channel adapters**
  - **used to preserve properties of a given interface**
  - **example:**

    lossless communication realized with a lossy medium

    (retransmission + acknowledge)

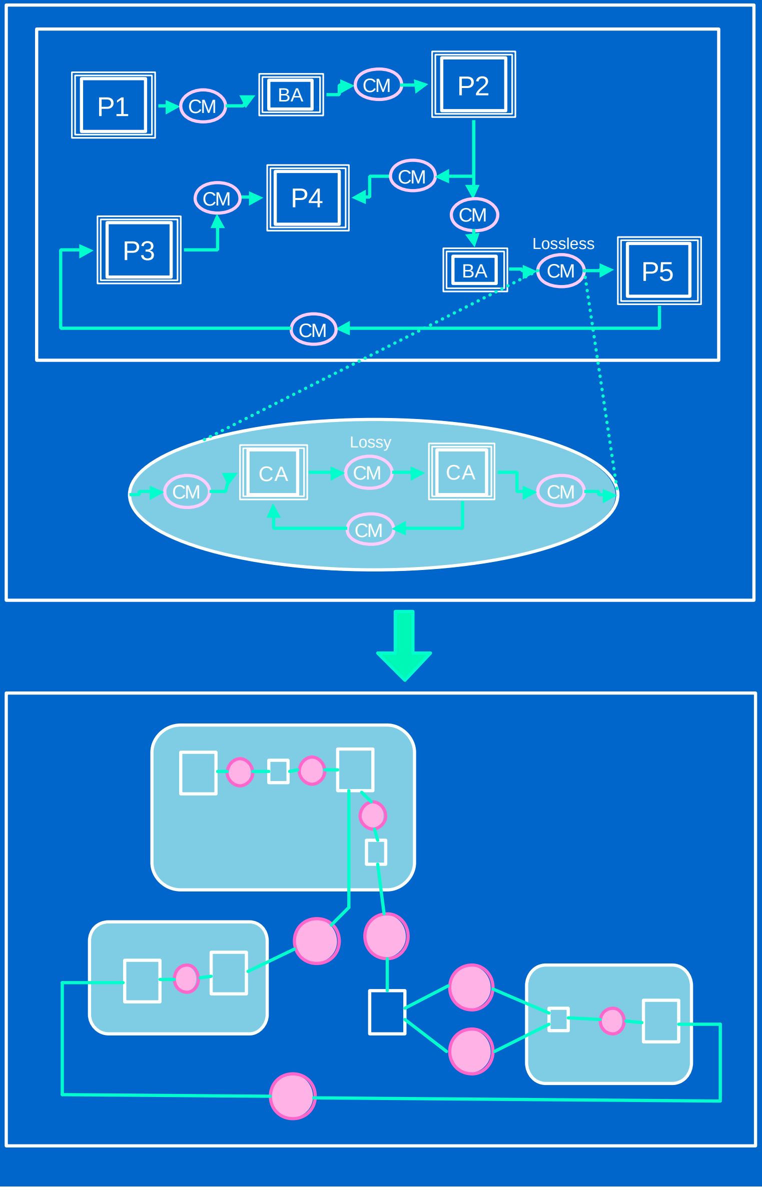


Refinement (ex.)

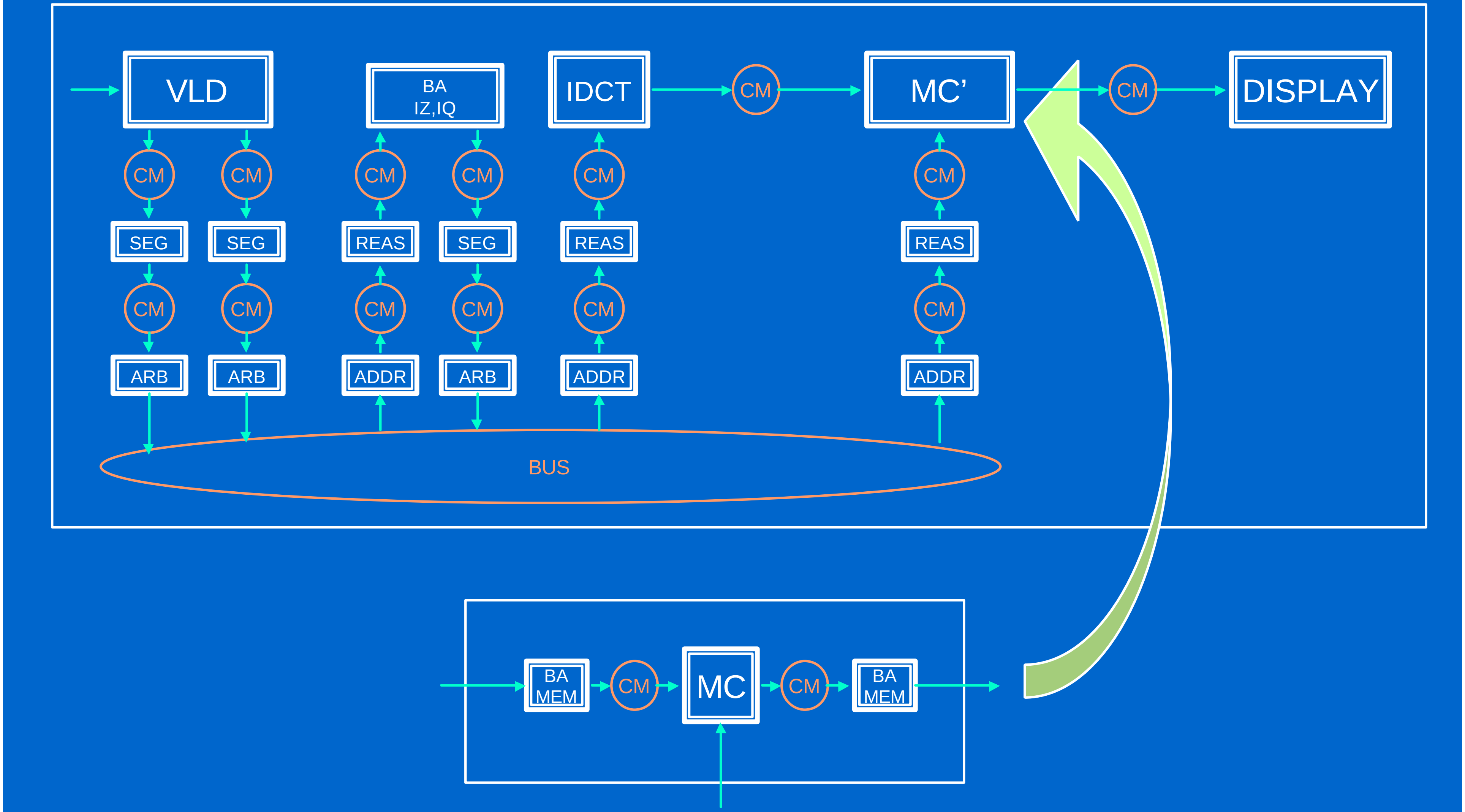


Mapping and Optimization

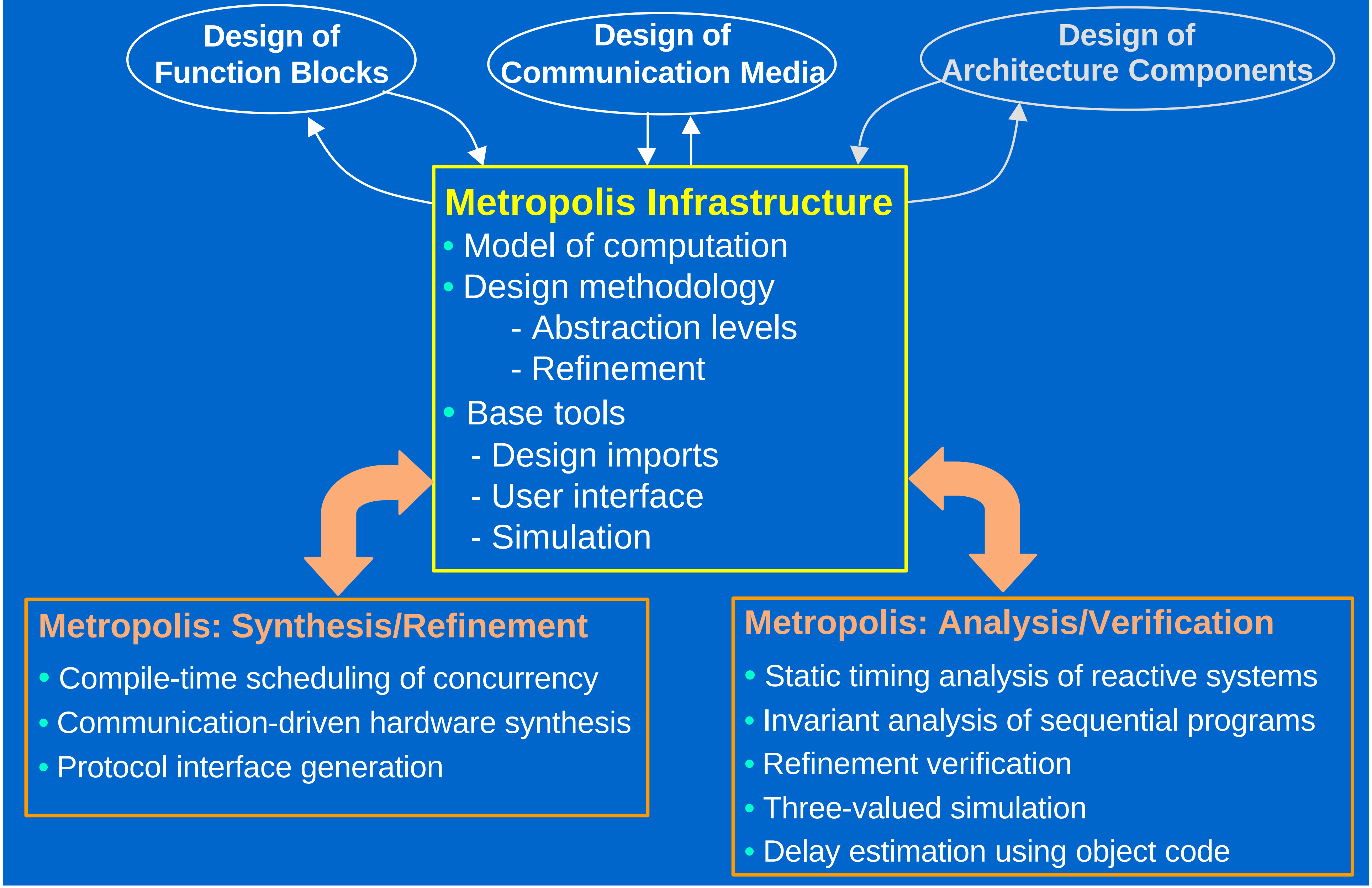
- **Optimization**
  - **map each element (processes, adapters, media) onto architecture**
  - **merge processes, adapters and media into a single process, when applicable**
  - **provide an imperative description for each process**



Mapping and Optimization (ex.)



Metropolis Framework



Design of Function Blocks

Design of Communication Media

Design of Architecture Components

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Metropolis: Synthesis/Refinement

- Compile-time scheduling of concurrency
- Communication-driven hardware synthesis
- Protocol interface generation

Metropolis: Analysis/Verification

- Static timing analysis of reactive systems
- Invariant analysis of sequential programs
- Refinement verification
- Three-valued simulation
- Delay estimation using object code