Introduction of SDL

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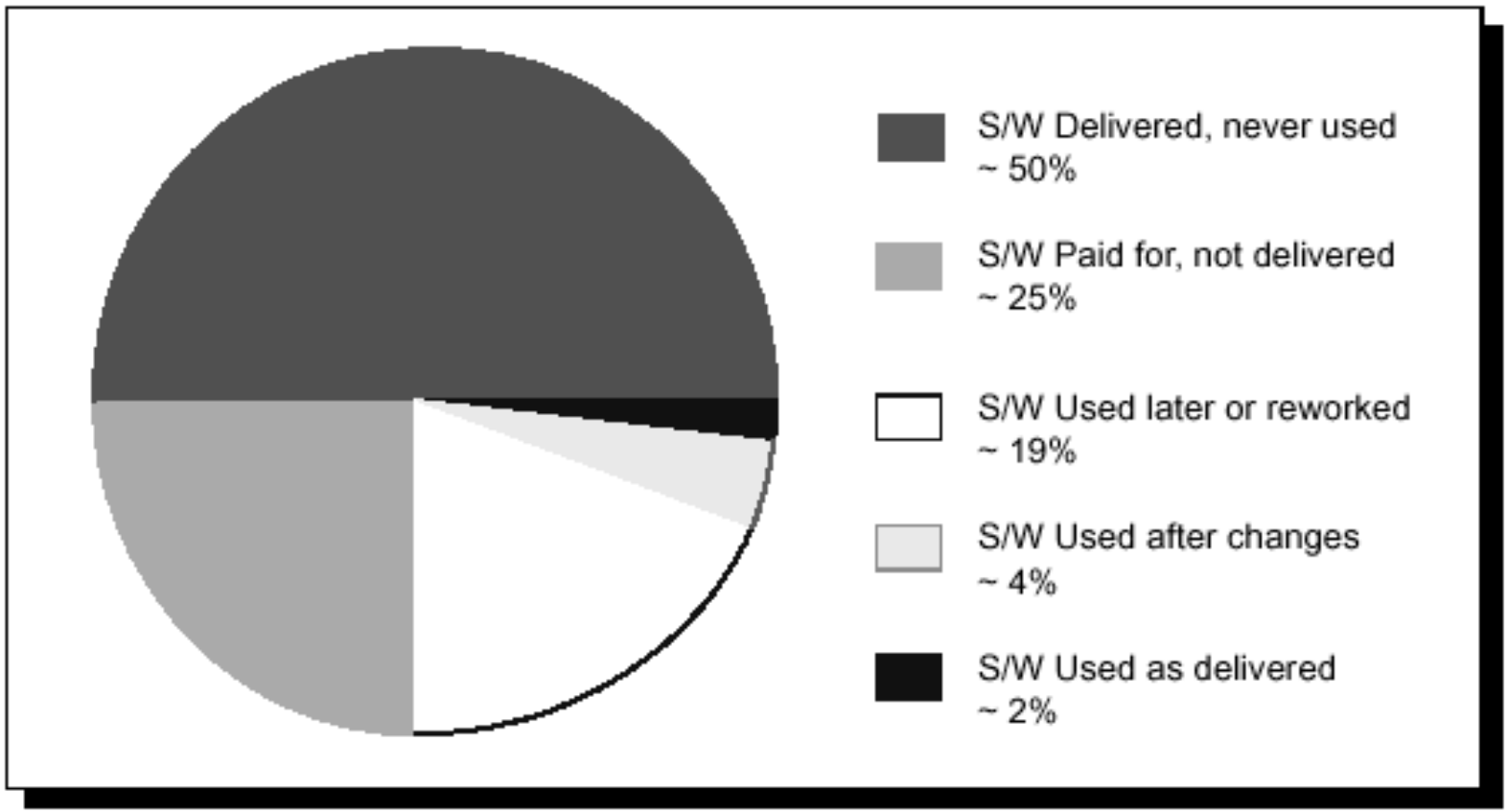
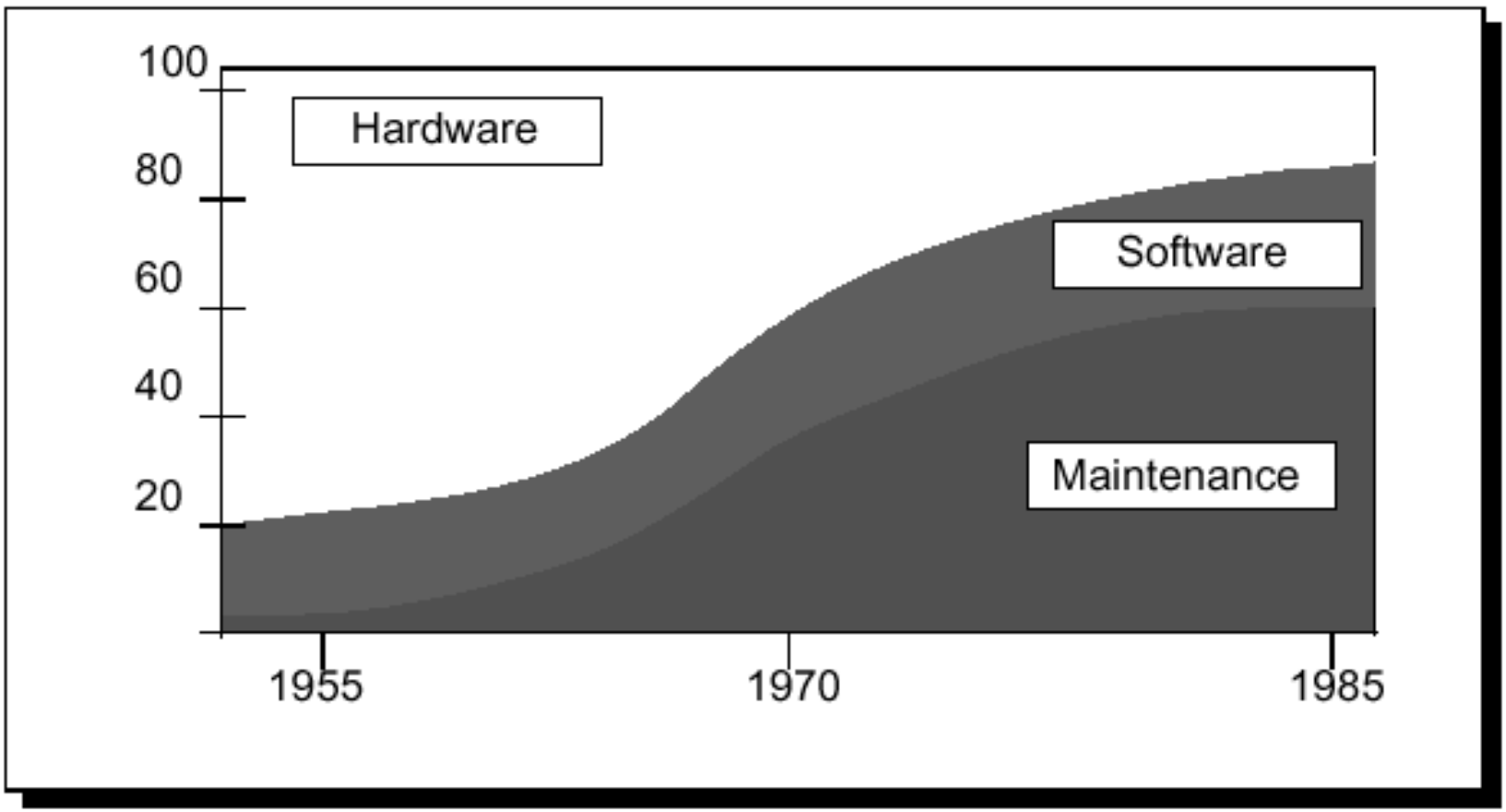
Software Projects Statistics



- *Collected by the United States Department of Defence from nine large software projects*

Software Costs



Specification and Description Language

✪ Specification

-- *A specification of a system is the description of its required behaviour*

✪ Description

-- *A description of a system is the description of its actual behaviour*

✷ The Purpose of SDL

Provide a language for unambiguous specification and description of the behaviour of telecommunications systems.

Objective of SDL

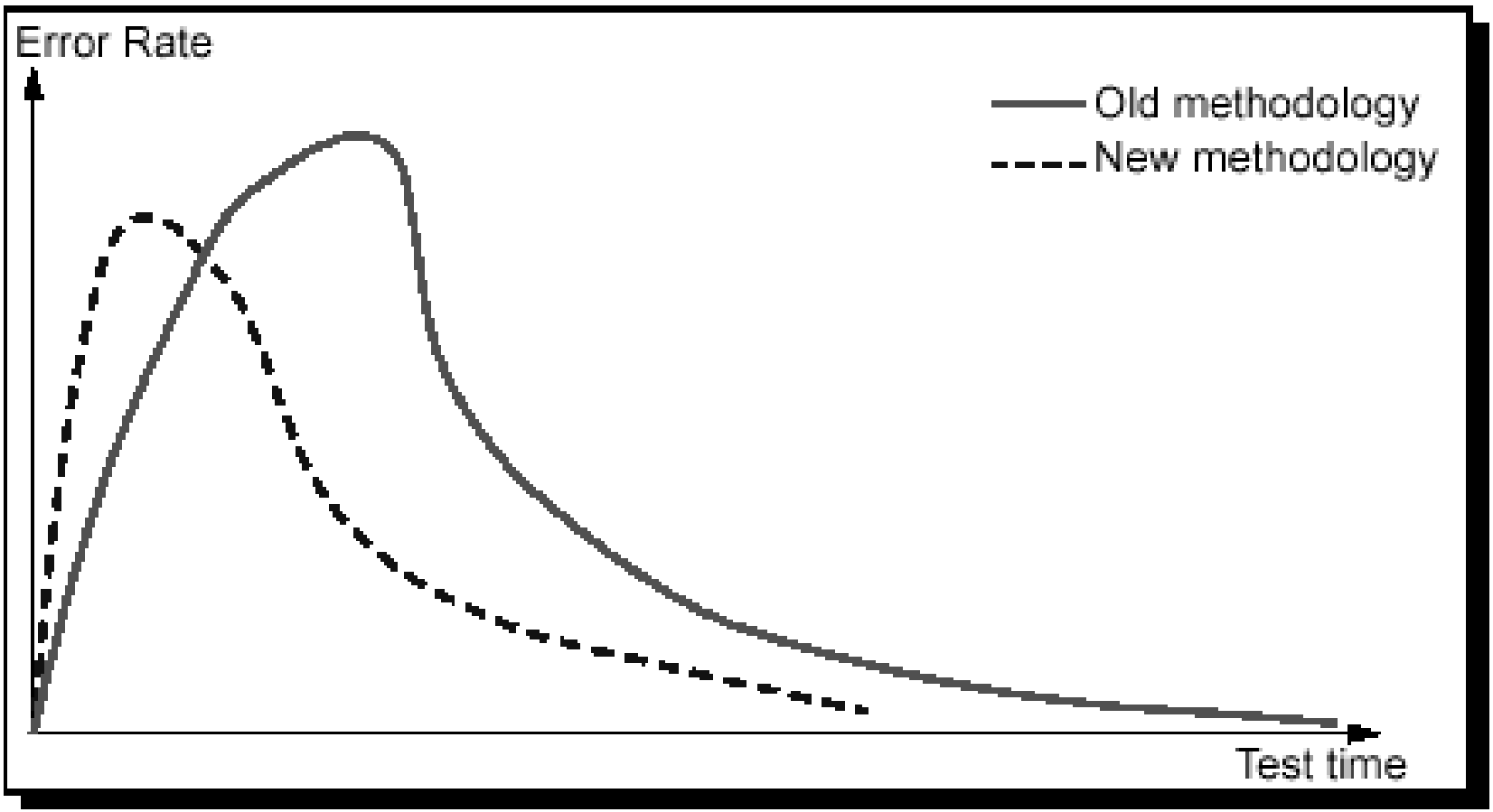
- Formal description technique
- Easy to understand both for creators (direct users) and viewers ("non constructors" of specifications)
(graphical representation)
- Object oriented language
- Independent of design paradigm
(e.g. function or object oriented)
- Independent of implementation
(language, operating system, and hardware)

Usage of SDL

a) facility requirements;
b) system specifications;
c) ITU-T Recommendations, or other similar Standards (international, regional or national);
d) system design specifications;
e) detailed specifications;
f) system design descriptions (both high level and detailed enough to directly produce implementations);
g) system testing descriptions (in particular in combination with MSC and TTCN).

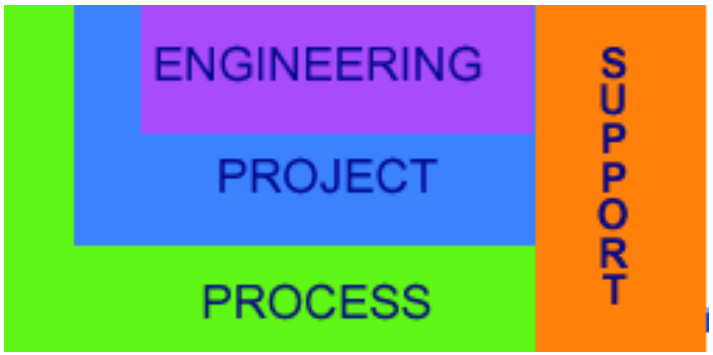
(From ITU-T Z.100)

Improvement of Error Rate



Source: Software Process Improvement with SDL, K. Kimbler, G. Opsahl, SDL Forum 1995

Process Dimension - CMMI



Process Management
- Organizational Process Focus
- Organizational Process Definition
- Organizational Training
- Organizational Process Performance
- Organizational Innovation and Deployment

Project Management
- Project Planning
- Project Monitoring and Control
- Supplier Agreement Management
- Integrated Project Management
- Integrated Teaming
- Risk Management
- Quantitative Project Management

Support
- Configuration Management
- Process and Product Quality Assurance
- Measurement and Analysis
- Decision Analysis and Resolution
- Causal Analysis and Resolution
- Organizational Environment for Integration

Engineering
- **Requirements Management**
- **Requirements Development**
- **Technical Solution**
- **Product Integration**
- **Verification**
- **Validation**

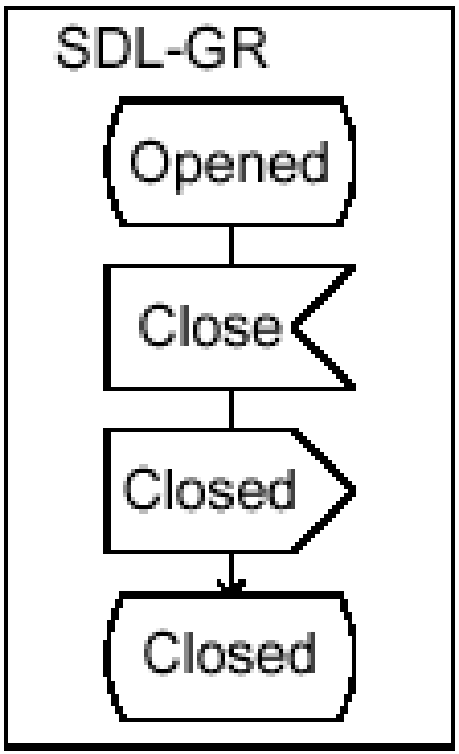
SDL History

- **International Standard (ITU-T, Z.100)**

SDL-76	First version. Only recommendations on how to draw process graph symbols (Behavior).
SDL-80	Blocks are introduced (Architecture), PR-form (textual Phrase Representation) becomes a part of the language.
SDL-84	The abstract data type concept is introduced (Data). Additional concepts are introduced.
SDL-88	Only minor changes
SDL-92	Object-oriented extensions to SDL
SDL-96	Minor changes (e.g. external procedures)
SDL-2000	Changes regarding architecture and data model.

Representations of SDL

- **Graphical**



- **Textual**

```
SYSTEM A;
SIGNAL
  sig1,
  sig2(real);
CHANNEL c1
  FROM B TO ENV WITH sig2;
  FROM ENV TO B WITH sig1, sig2;
ENDCHANNEL c1;
BLOCK B REFERENCED;
ENDSYSTEM A;
```

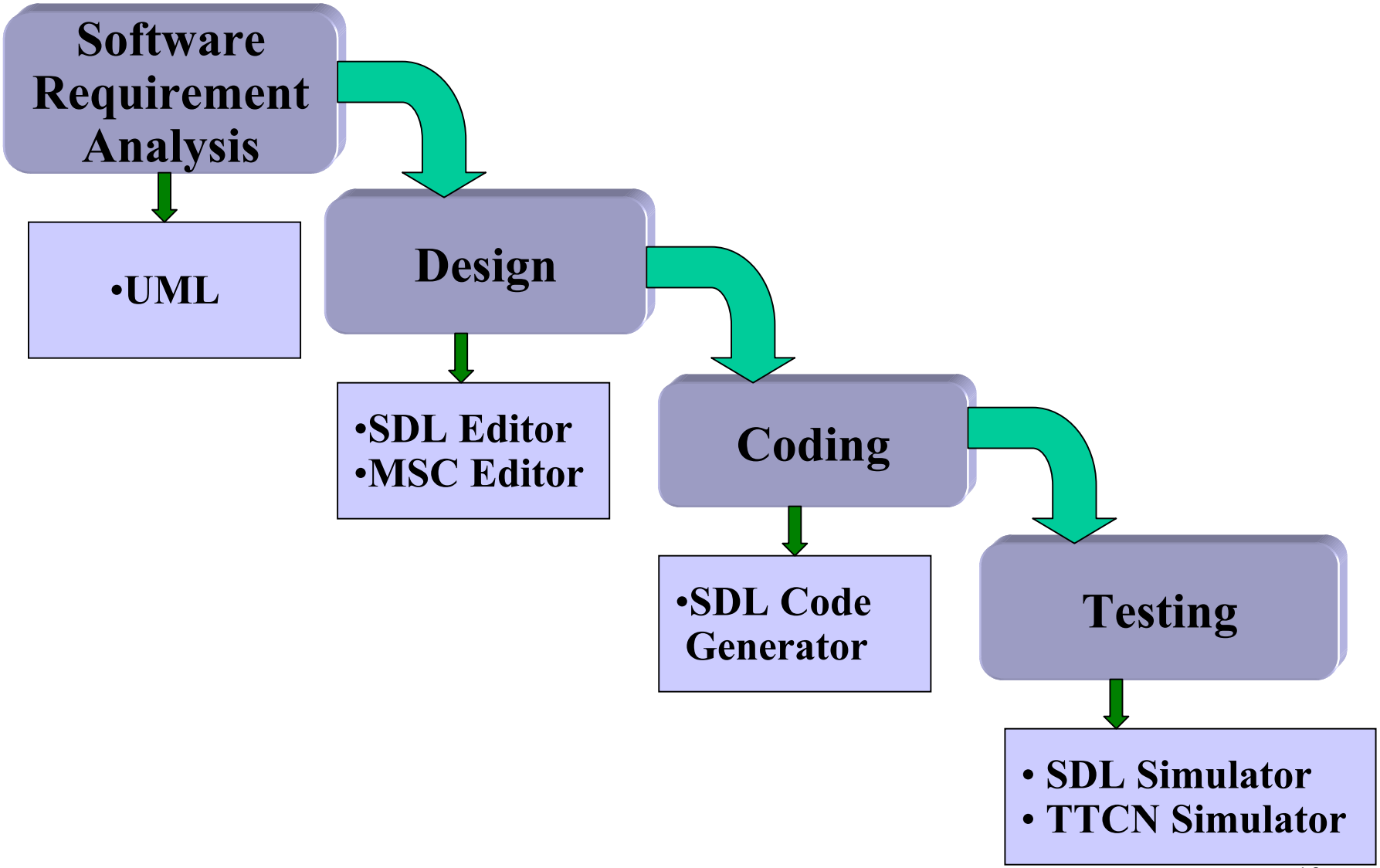
Application of SDL

- call and connection processing
  (for example, call handling, telephony signalling, metering)
  in switching systems
- maintenance and fault treatment
  (for example alarms, automatic fault clearance, routine tests)
  in general telecommunications systems
- system control
  (for example, overload control, modification
  and extension procedures)
- operation and maintenance functions, network management
- data communication protocols
- telecommunications services

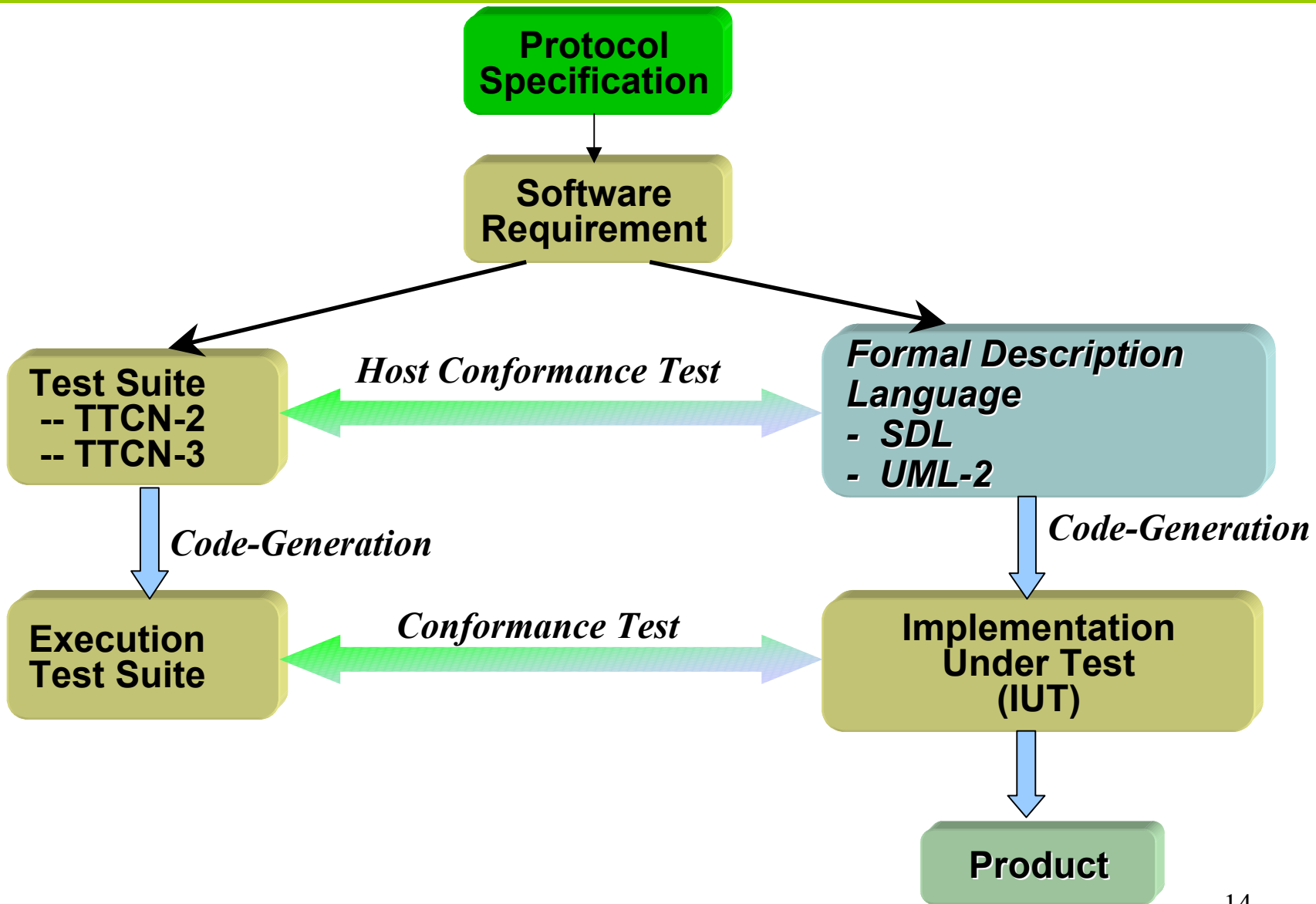
SDL Design Methodology

- Flow of Software Development
- Basic Concept of SDL Design Flow
- Basic Component of SDL

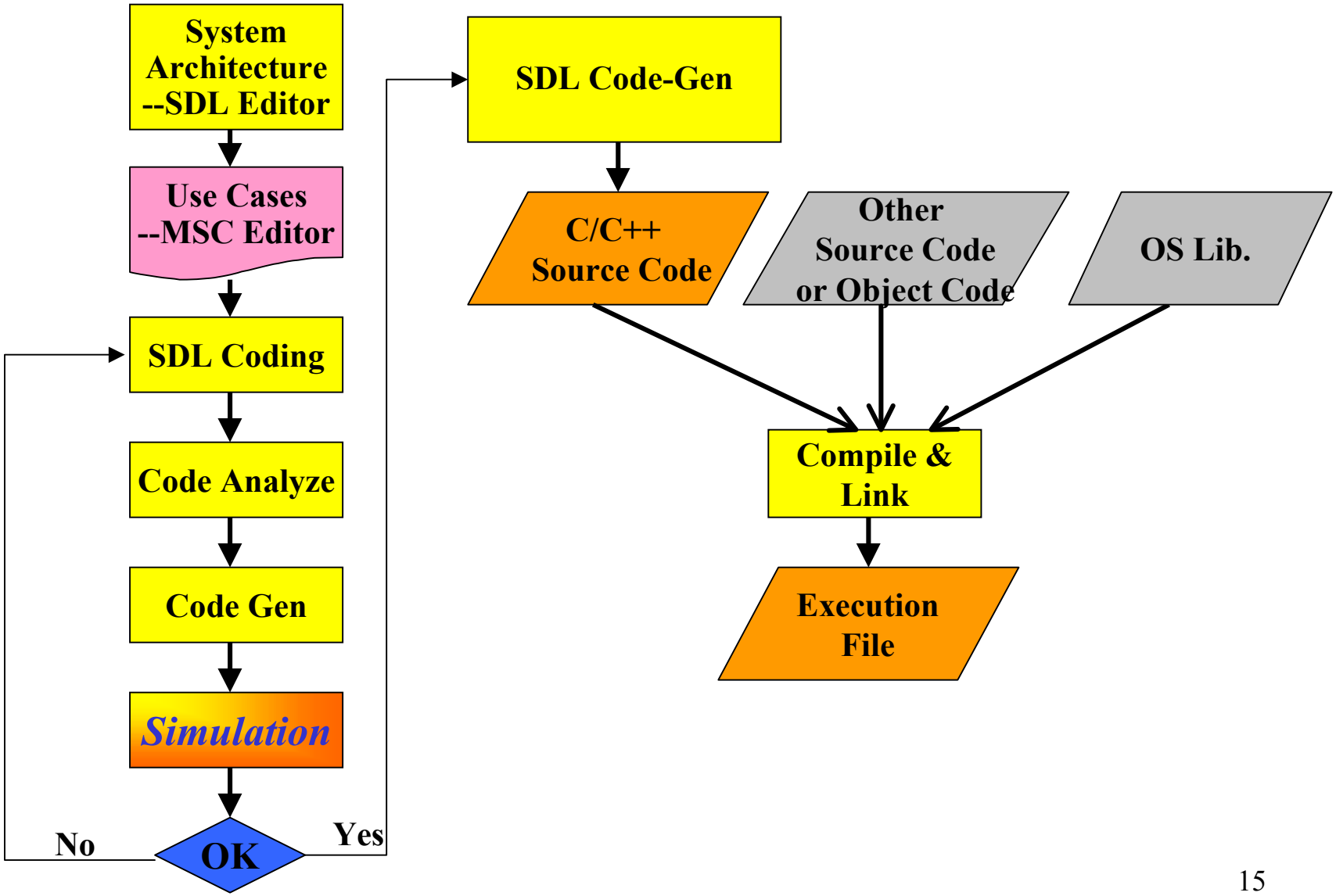
Flow of Software Development



Protocol Development Process



Basic Concept of SDL Design Flow



Basic Component of SDL

- **Architecture**
  - system, block
- **Behavior**
  - processes
- **Communication**
  - signals and channels
- **Data**
  - abstract data types

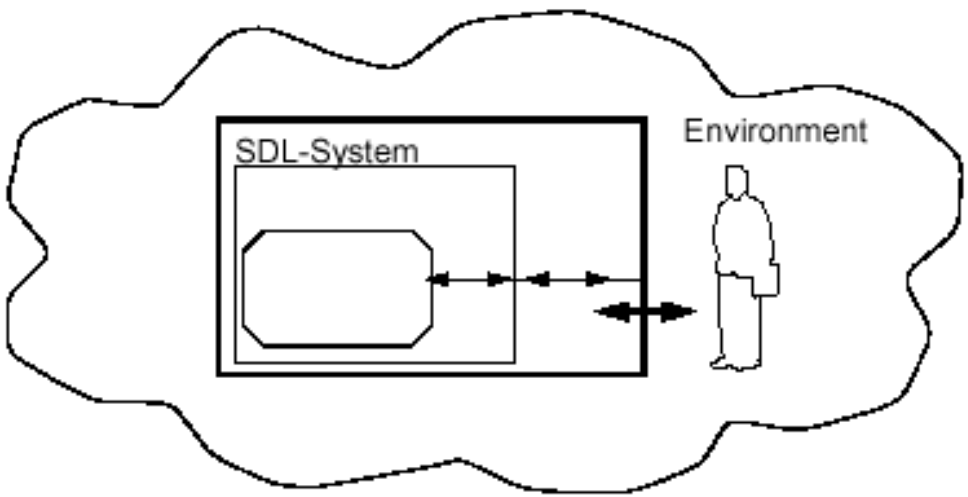
SDL Architecture -- System

✷ **SDL System**

A SDL-system is the outermost agent that communicates with the environment.

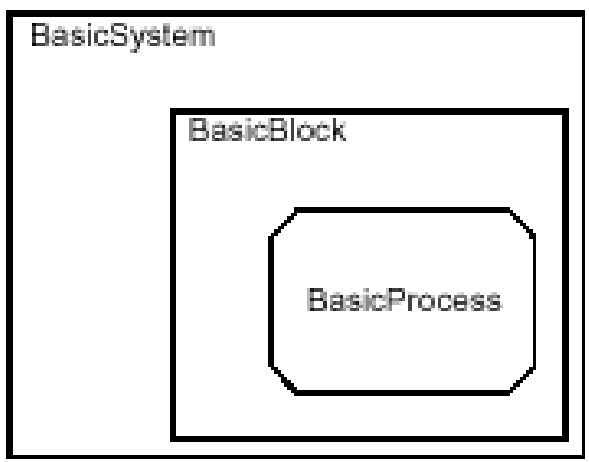
✎ **Environment** :

The environment of the system is everything in the surroundings that communicates with the system in an SDL-like way.



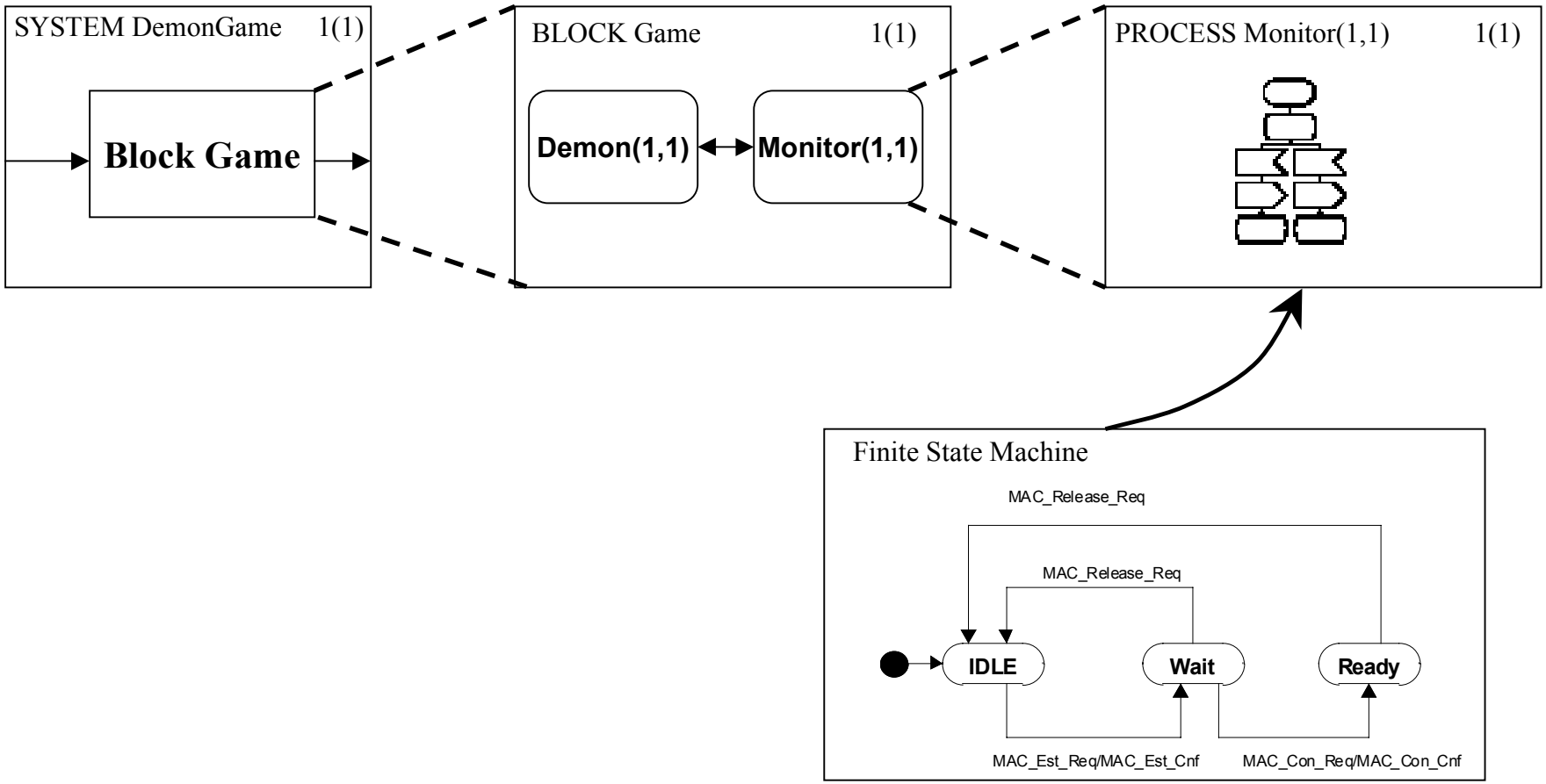
SDL-System Structural Concepts (1)

- A SDL System must define the interfaces to communicate with other components
  - A complete SDL system must contain at least one block
    - A block must contain at least one process or block, blocks and processes must not be mixed in one block.
      - A process must contain an finite state machine



SDL-System Structural Concepts (2)

Hierarchical Structure



SDL-System Structural Concepts(3)

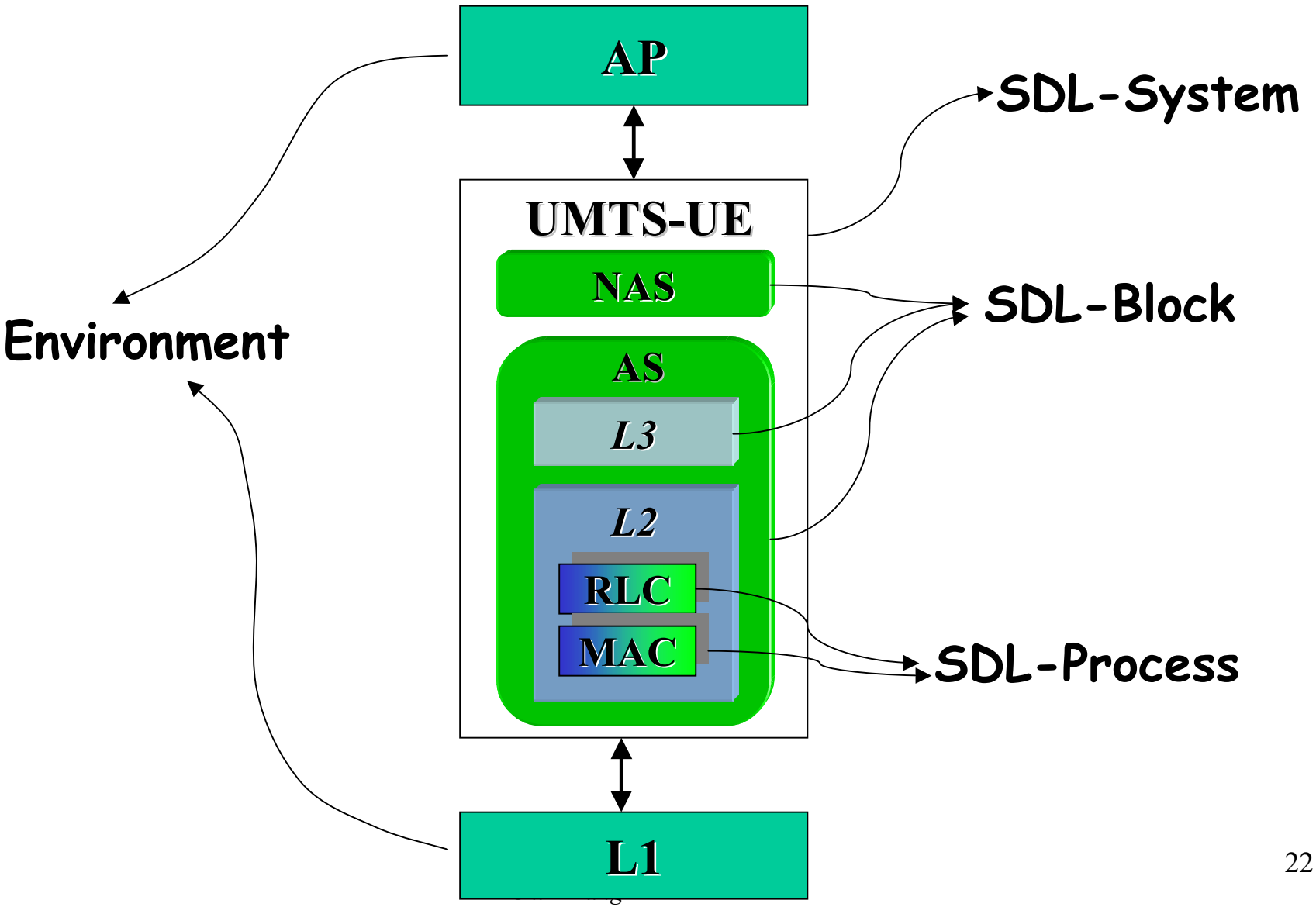
A SDL System can contains :

- **System Name**
- **SDL Blocks**
- **Channels**: The relation between the system and the 'outside world'.
- **Signal Definition**
- **Data Type Definition**

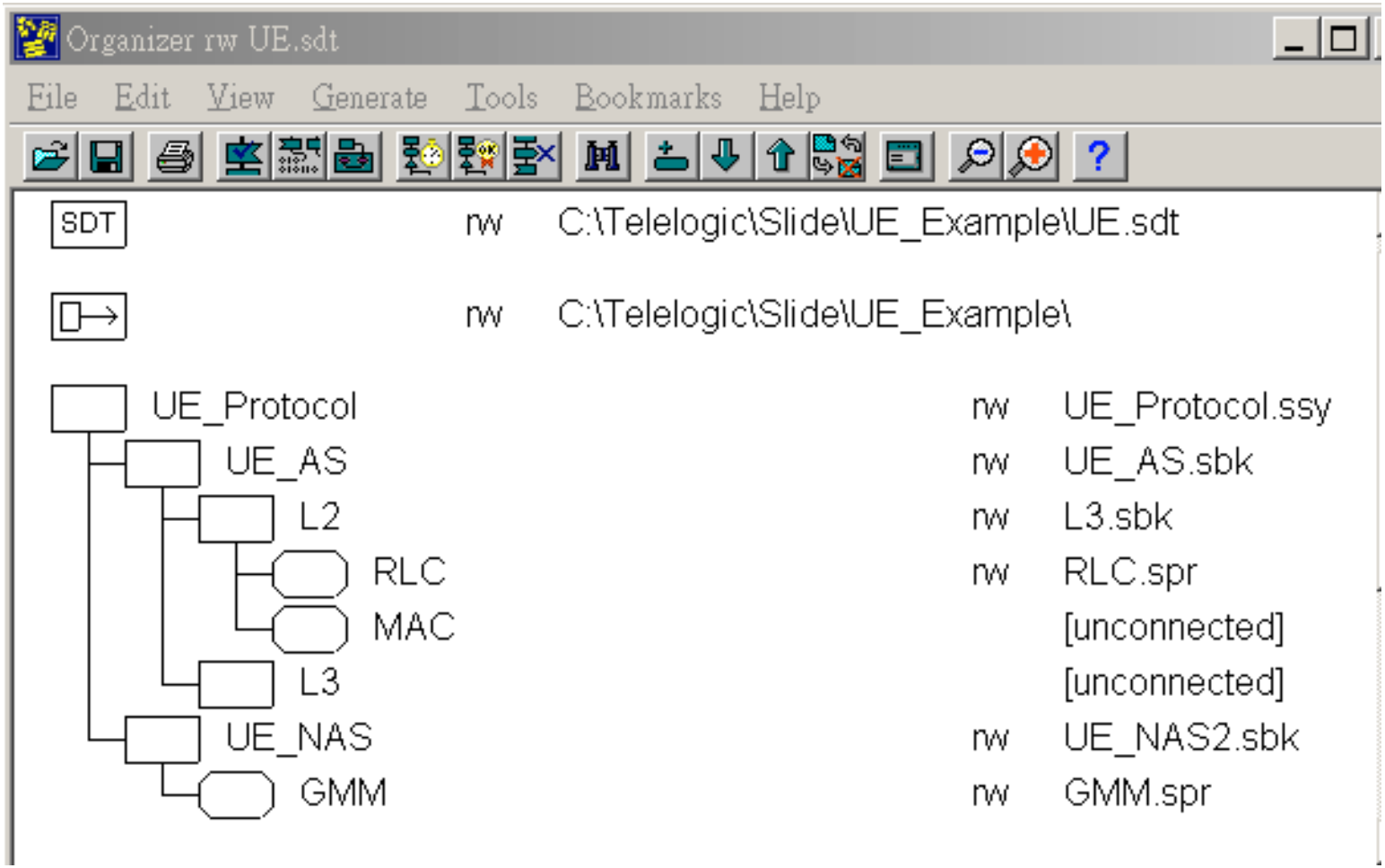
SDL-Block

- A block can be refined either by a set of ***processes*** or by a set of ***block substructures***.
- Blocks are static entities in SDL.

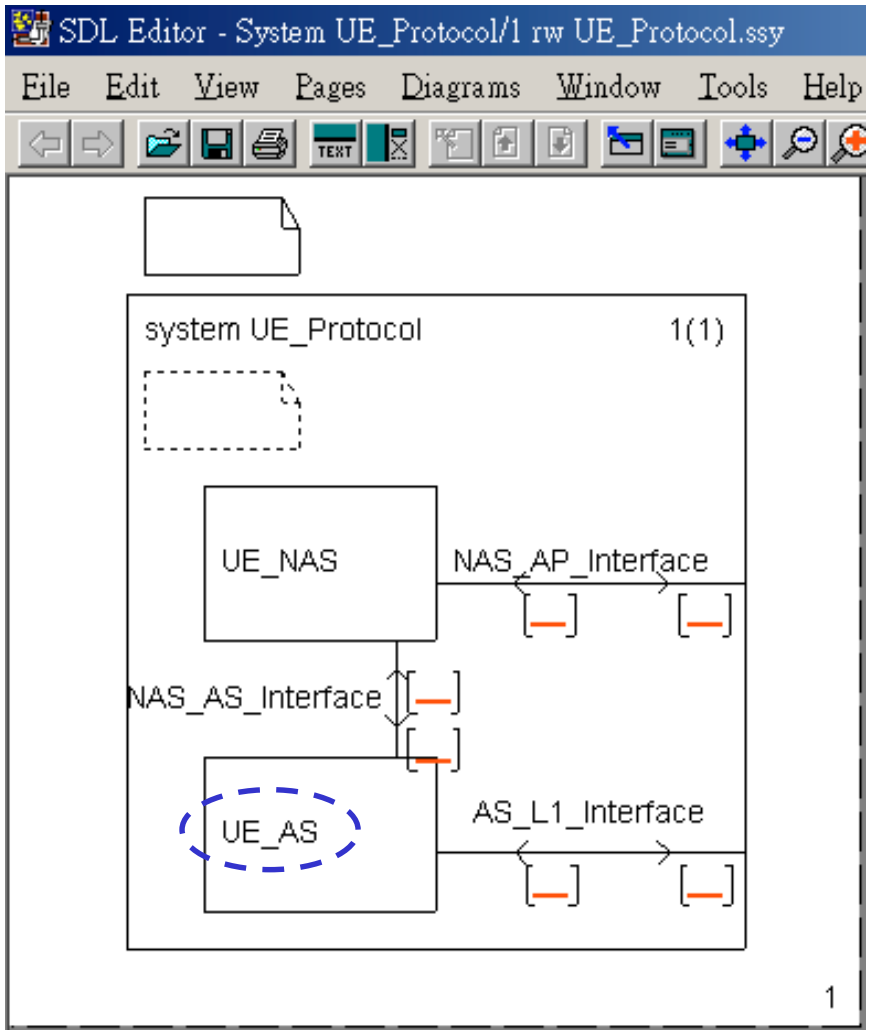
SDL-System Example (1)

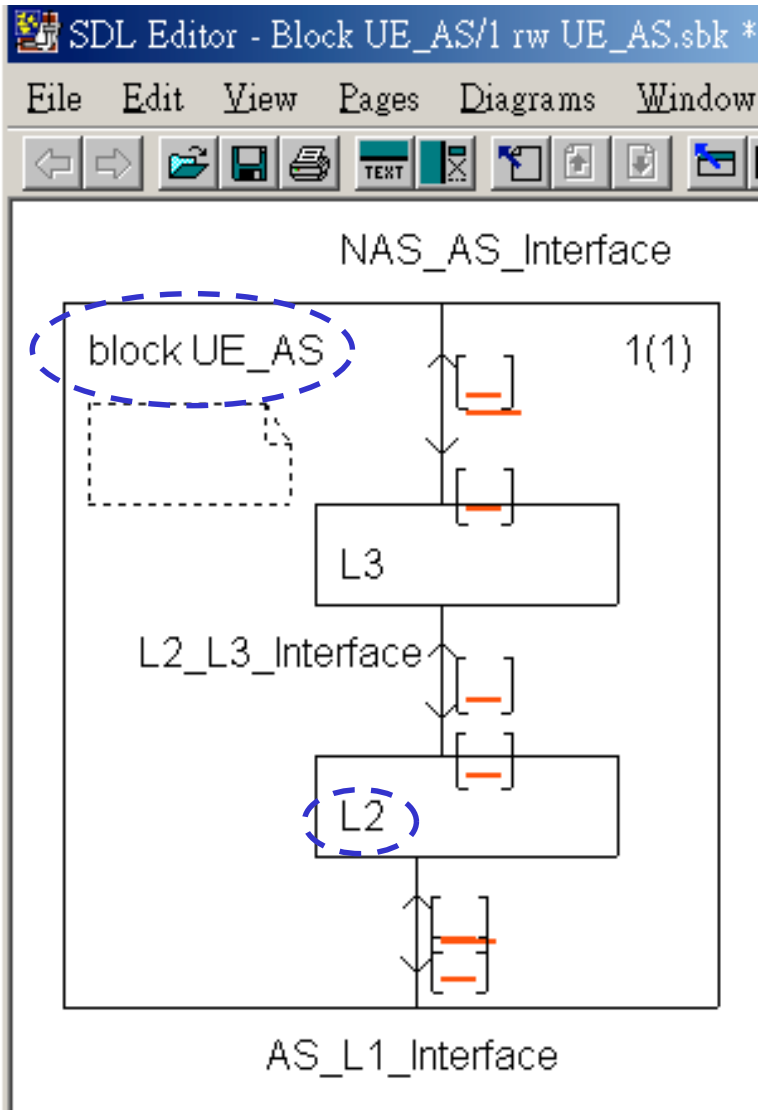


SDL-System Example (2)

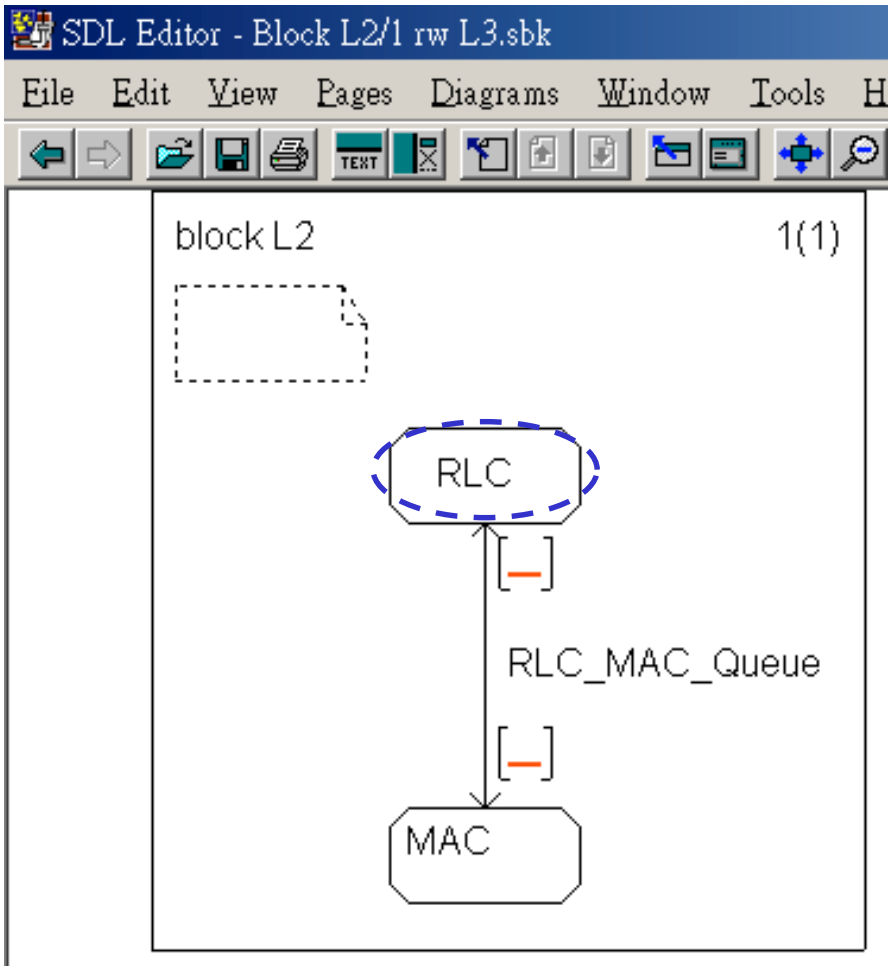


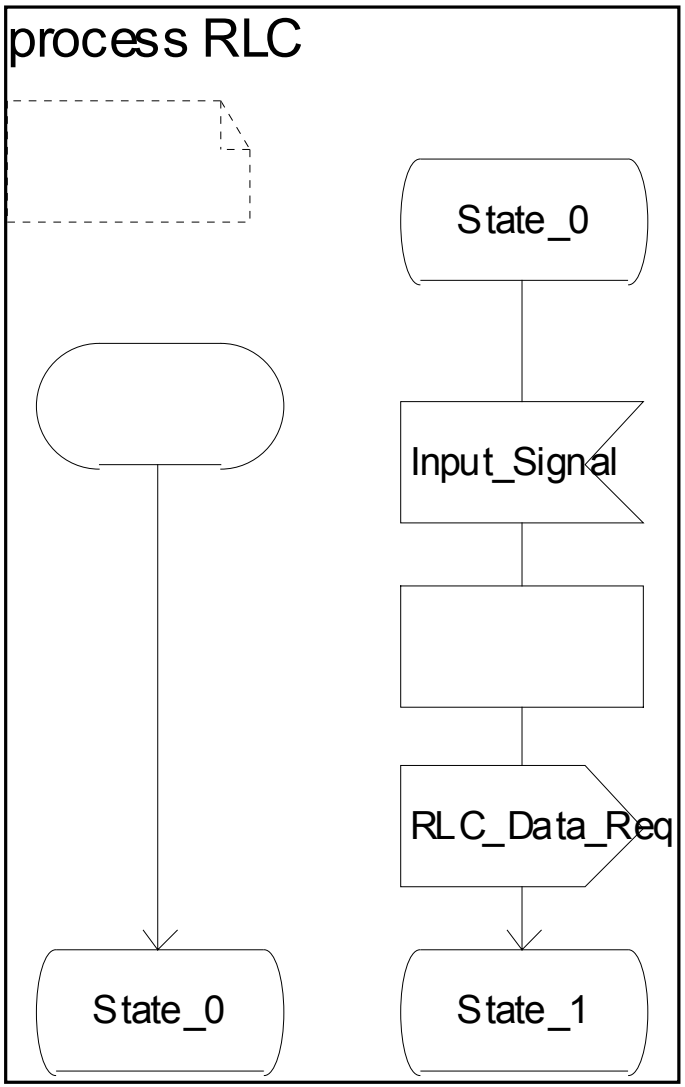
SDL-System Example (3)





SDL-System Example (4)





SDL Process

- Processes are the actors of SDL systems.
- An SDL process is the active unit of an SDL system.
- An SDL process represents an ***extended finite state machine.***
- Processes may be defined with an initial and a maximum number of instances
- SDL processes can communicate by means of asynchronous message passing with other processes.

Elements of SDL Process

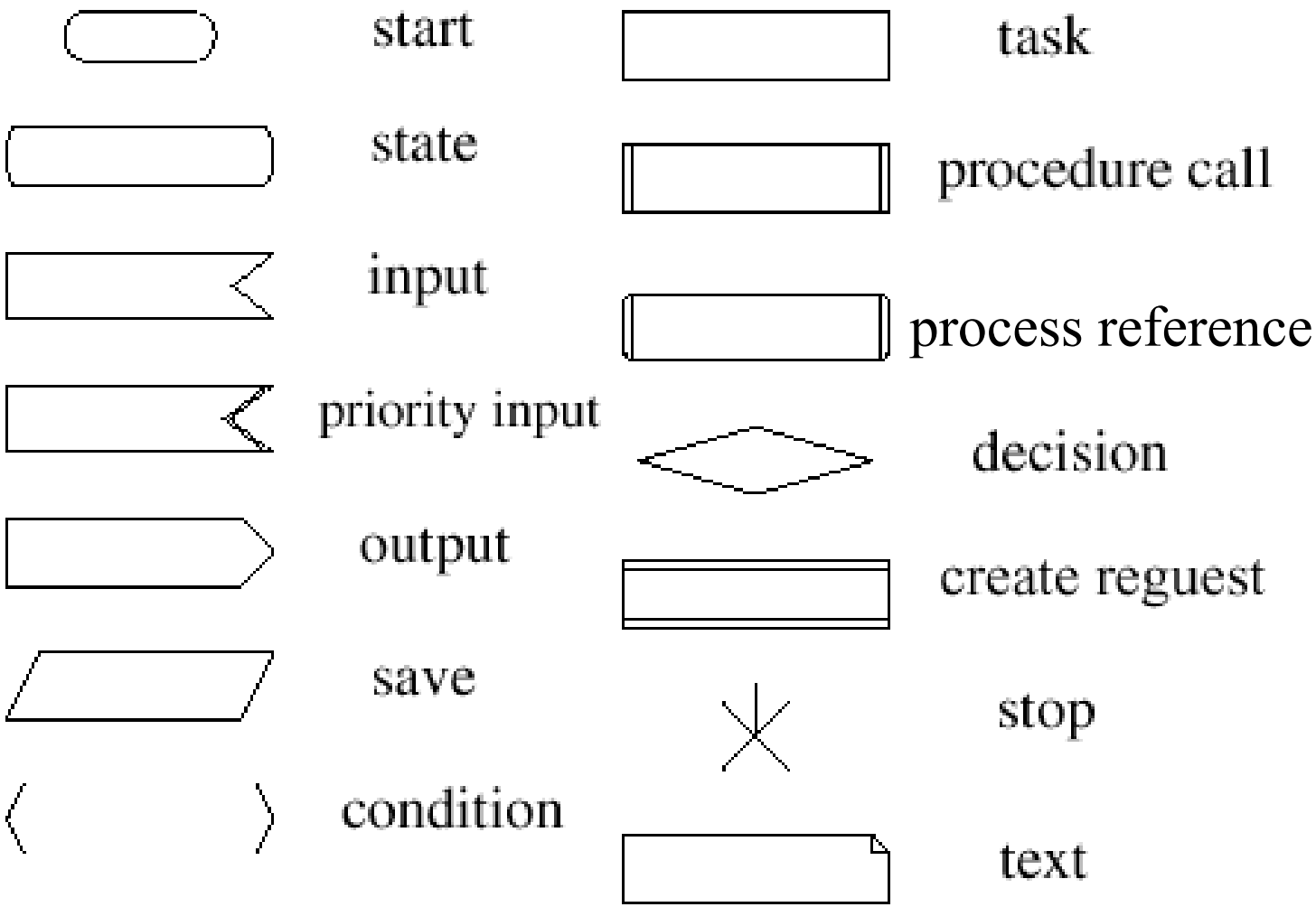
- ***The SDL Process may contain:***
  - Process name
  - Formal Parameters
  - Local Variables
  - Time and timers
  - The graphical representation of a FSM

Behavior of SDL

✧ *SDL Process as Finite State Machine*

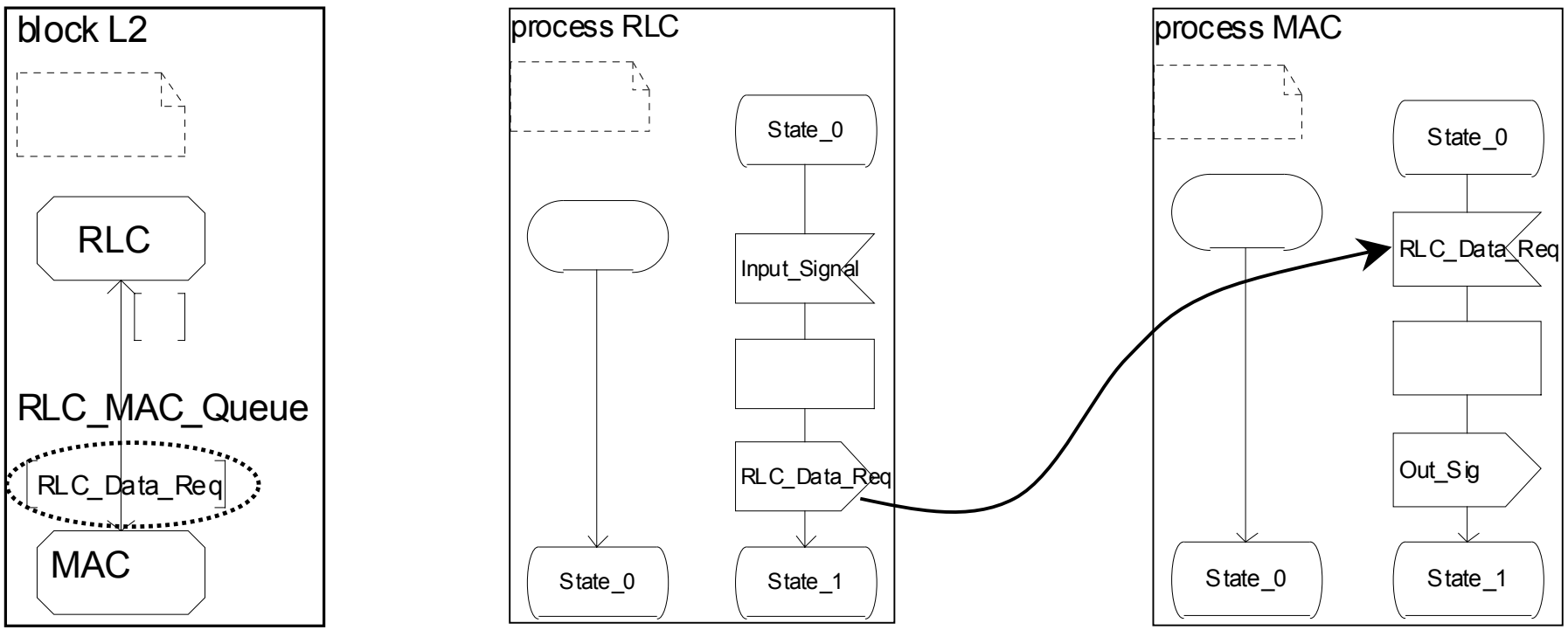
- In SDL ,the FSM is extended with data processing (EFSM)
- "Send no wait", asynchronous signalling
- Process instances can be created and terminated dynamically
- A process is activated by means of an arriving signal. At the end of a transition the next state is entered.

Process Symbols



Input / Output Symbol

- The **RLC** will send ***RLC_Data_Req*** to **MAC** via ***RLC_MAC_Queue***



Input Port

- Each process instance has a FIFO queue of its own
- The port allows received signals (and timeouts)to be queued until they are consumed (or discarded) by the owning process instance.
- The queues have an infinite capacity.
- The FIFO order in processing the queue is **NOT** always preserved(because of priority/save).

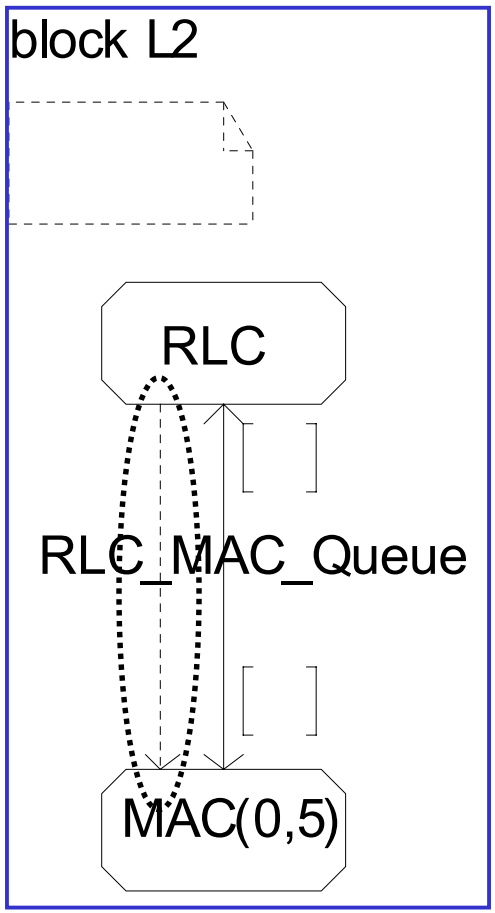
SDL Process ID

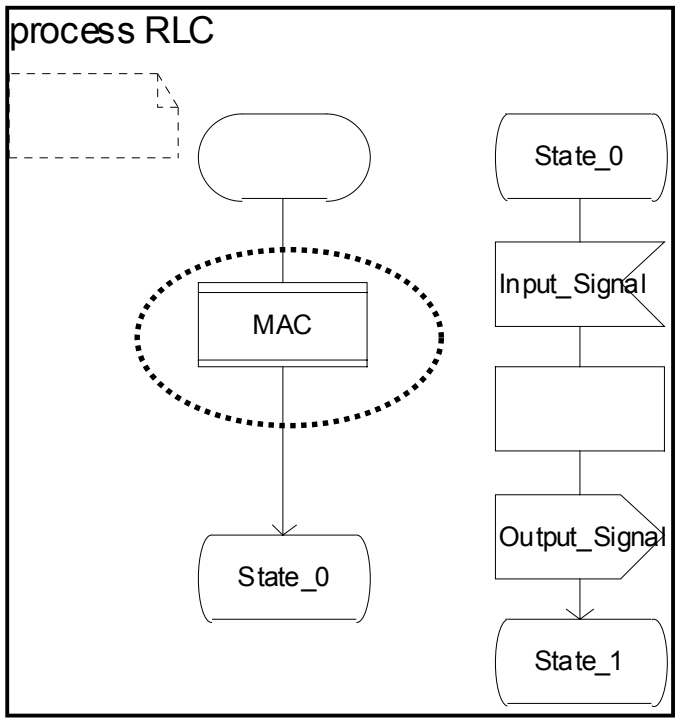
- Each SDL process maintains a set of intrinsic variables which are of the predefined data type **PId** (Process Identity)

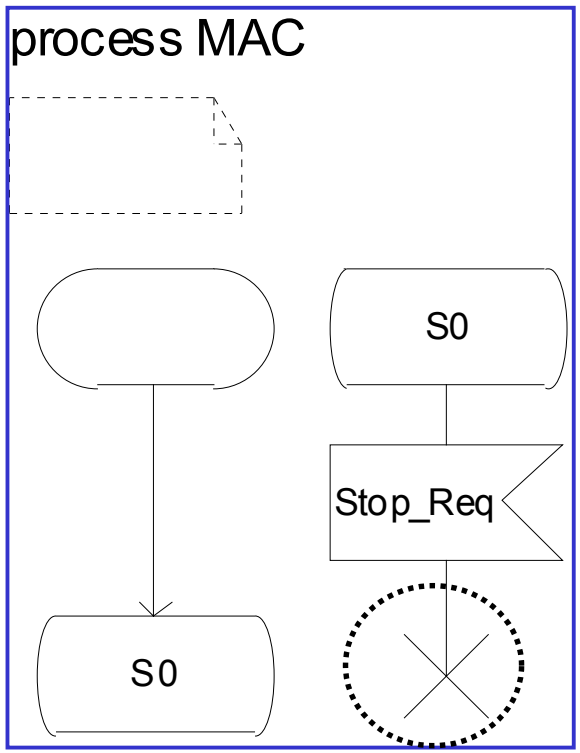
  - ***self :*** Denotes the PId of the process instance itself
  - ***sender:*** Denotes the PId of the process instance from which the most recent signal has been consumed
  - ***parent:*** Denotes the PId of the process instance that has created the instance
  - ***offspring:*** Denotes the PId of the most recent process instance created by this process instance.

Dynamic Process Creation

- Created processes must lie in the same block.
- Termination of a process can only be made by itself.





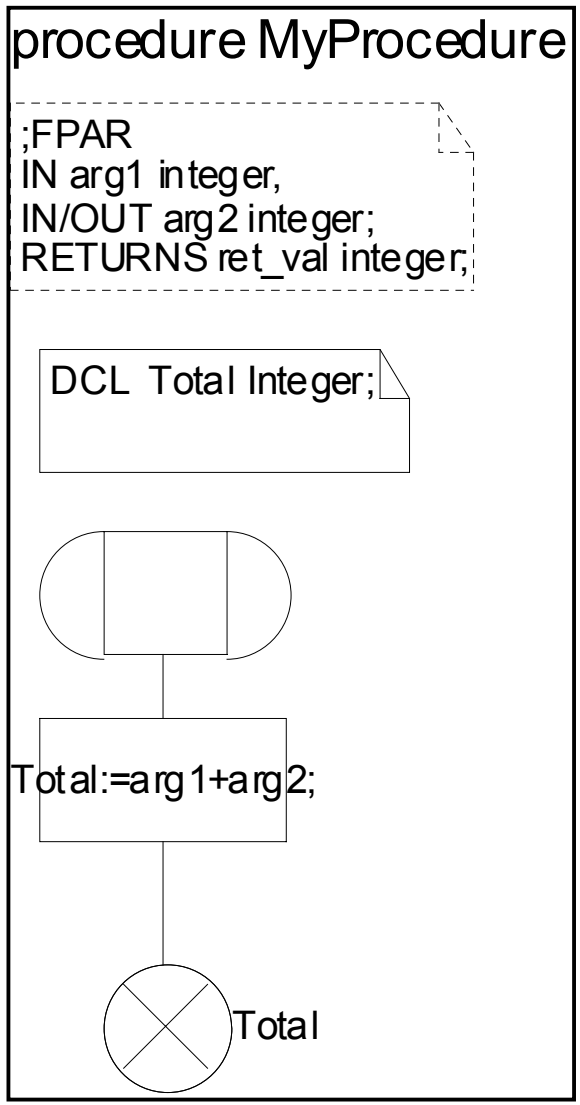


SDL Procedure

- Procedures can have IN or IN/OUT parameters.
- Procedures can return a value.
- SDL procedures can contain states and variable declarations.
- Procedure states are disjoint from process state space.
- Procedures can see the variables of the owning process.
- Procedures can only use timers declared in the owning process.

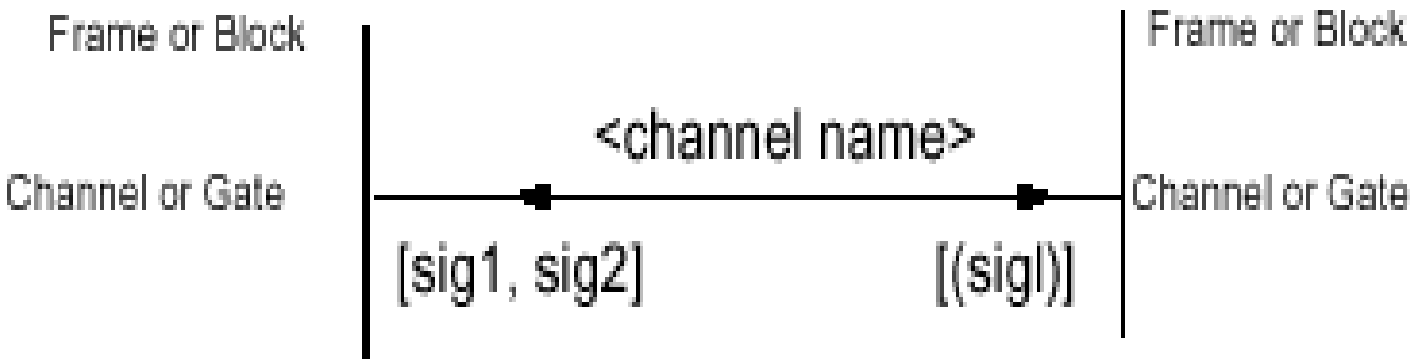
SDL Procedure

Ret_val:=call MyProcedure(1,my_arg)



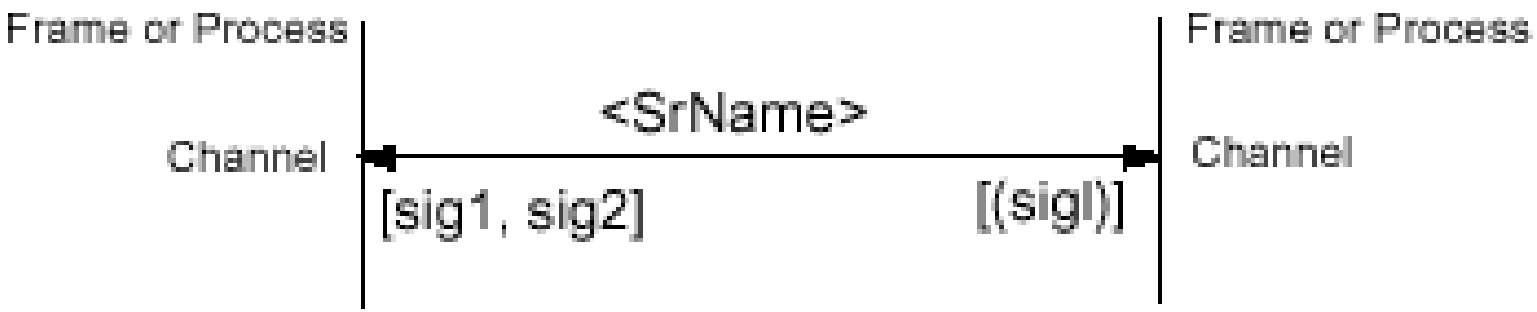
SDL Channel

- Communication path between blocks itself and between blocks and the environment
- Channels can be unidirectional or bidirectional communication devices.



SDL Route

- A signal route defines a communication path between a process and its environment or another process.



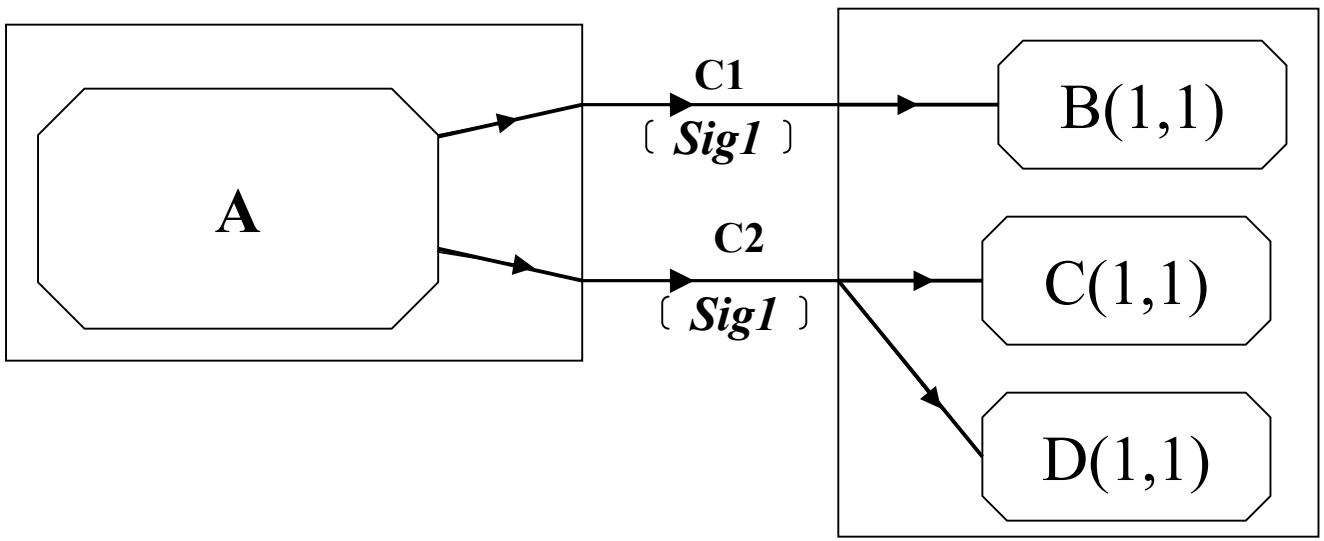
Signals

- Signals are the primary communication mechanism in SDL
- Signals may carry data by means of parameters.
- All signals to and from the environment are declared at system level.
- Signals can be defined inside a block (thus only visible in the block)

Signal Addressing & Routing

☞ **If there are several possible receivers of a signal, the signal will be delivered to an arbitrary receiver.**

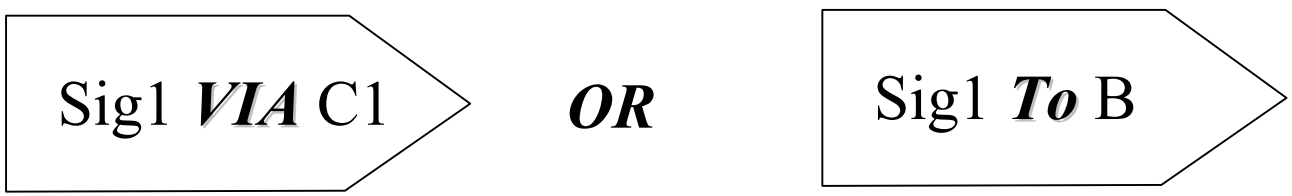
Example:



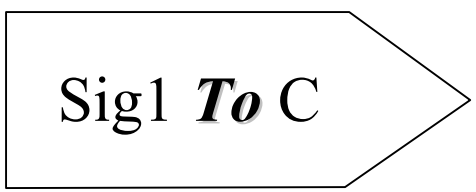
Signal Addressing & Routing

- **SDL provide two way for addressing:**
  - ***VIA*** : Specifies a signal path
  - ***TO*** : Specifies a receiving process

- ***Example 1:*** **A Send *Sig1* to B**



- ***Example 2:*** **A Send *Sig1* to C**



SDL Data

- **Based on abstract data types**

  - An abstract data type defines a type of data object by its functional properties,i.e.by a set of operations applied to it.

- **In SDL,data types are called "*sorts*"**
- **Variables can only be declared in processes**

  - No global variables.

- **In SDL inheritance and generics are supported**
- **A new data type is defined by:**

  - constants and a set of values
  - operators
  - axioms

SDL Predefined Data Sorts

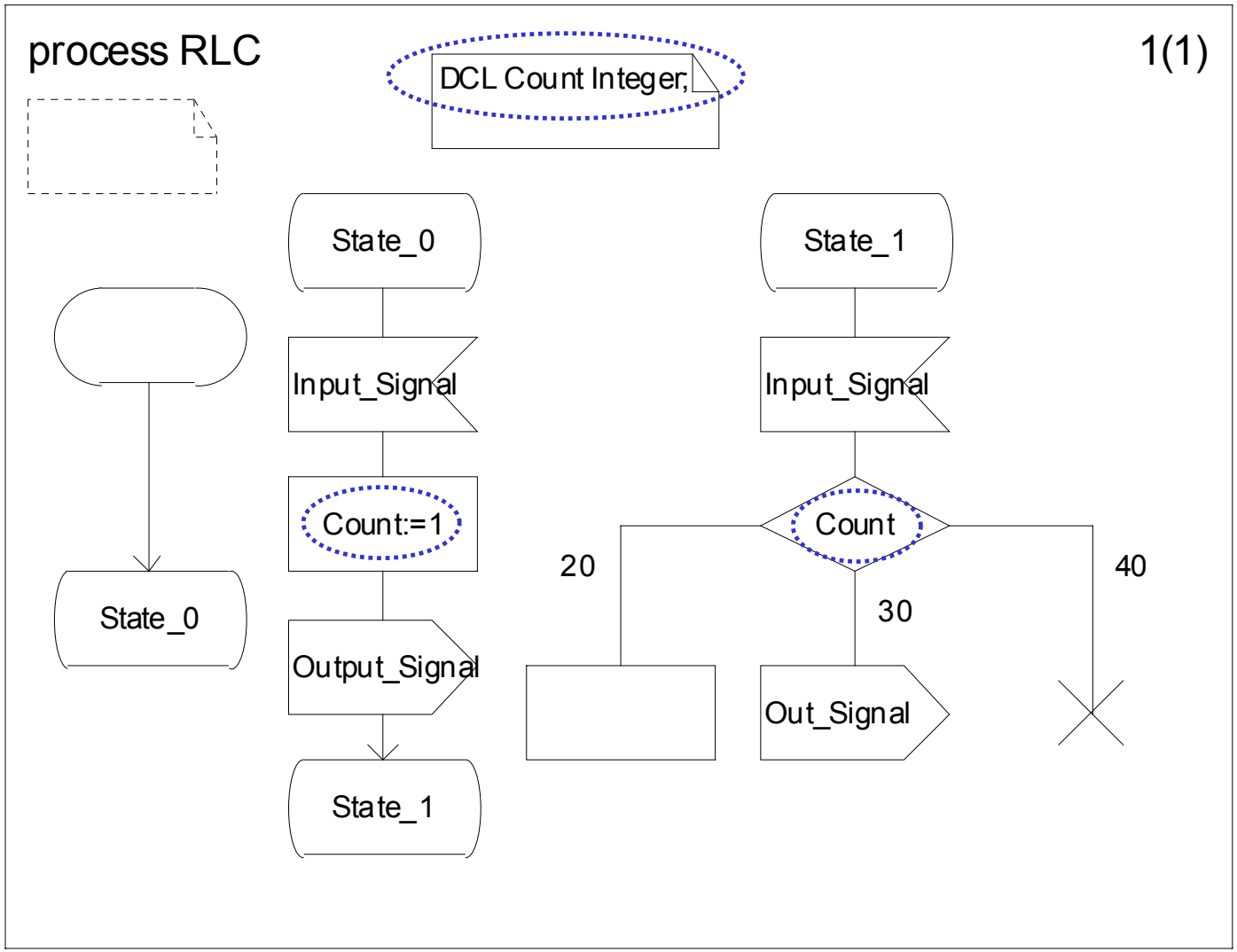
- Integer
- Natural
- Real
- Boolean
- Character
- Charstring
- PId
- Duration
- Time

Boolean

- Boolean is a typical example of a data type in SDL

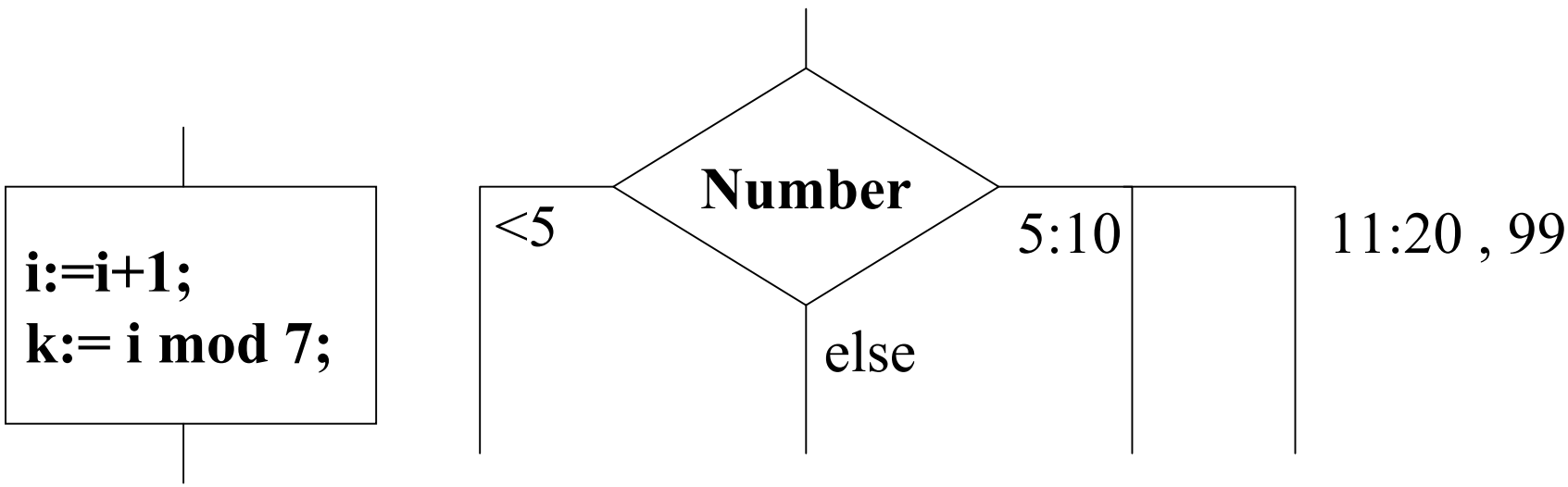
```
NEWTYPE Boolean
LITERALS True, False;
OPERATORS
"NOT":Boolean ->Boolean;
"=" :Boolean, Boolean ->Boolean;
"/=":Boolean, Boolean ->Boolean;
"AND":Boolean, Boolean ->Boolean;
"OR":Boolean, Boolean ->Boolean;
"XOR":Boolean, Boolean ->Boolean;
"=>":Boolean, Boolean ->Boolean;
AXIOMS
"NOT"(True)== False;
"NOT"(False)== True;
...
ENDNEWTYPE Boolean;
```

Variable Declaration and Use



Task and Decision

- The "Task" symbol is used for assignments
- A decision is much like an *if* or *case* statement.



Synonym

- **With Synonym, constants are declared in SDL**
  - **Can be used in SDL-System or Blocks**
  - **If a constant is declared as EXTERNAL it means that the constant will be assigned first at system start-up time (i.e. it can be assigned different values each time).**

```
SYNONYM Zero Integer = 0;
SYNONYM One Integer = 1;
SYNONYM NrOfDoors Natural = EXTERNAL;
```

Newtype

- **Newtype creates a new data type**

```
Newtype SeqNum
    literals zero, one;
    operators
      succ :
 SeqNum -> SeqNum;
    axioms
      succ( zero) == one;
      succ( one) == zero;
Endnewtype SeqNum;

Newtype EyeColorType
LITERALS Blue, Brown
DEFAULT
Blue
Endnewtype EyeColorType;
```

```
DCL MySeqNum SeqNum;
DCL MyEye EyeColorType;
```

```
SeqNum := zero;
SeqNum := succ(SeqNum );
MyEye  := Brown;
```

Syntype

- **Restrict the set of values of a ground type**
  - ***NOTE! The syntype will not be a new type but a subtype, and can thus be assigned values of the ground type.***

```
SYNTYPE Age = Natural
CONSTANTS 0:100
ENDSYNTYPE Age;
```

```
DCL
MyAge, YourAge Age;
```

```
MyAge:=1,
YourAge:=100
```

Struct

- **Struct is a data type where the data structure is explicitly stated**
  - ***Struct in SDL is similar to struct in C-Language***

```
typedef enum
{
  type_802_11_a,
  type_802_11_b,
  type_802_11_g,
} Connect_Type;

typedef struct
{
  Connect_Type con_type;
  char id;
  int  timing ;
} Con_Req_Arg;
```

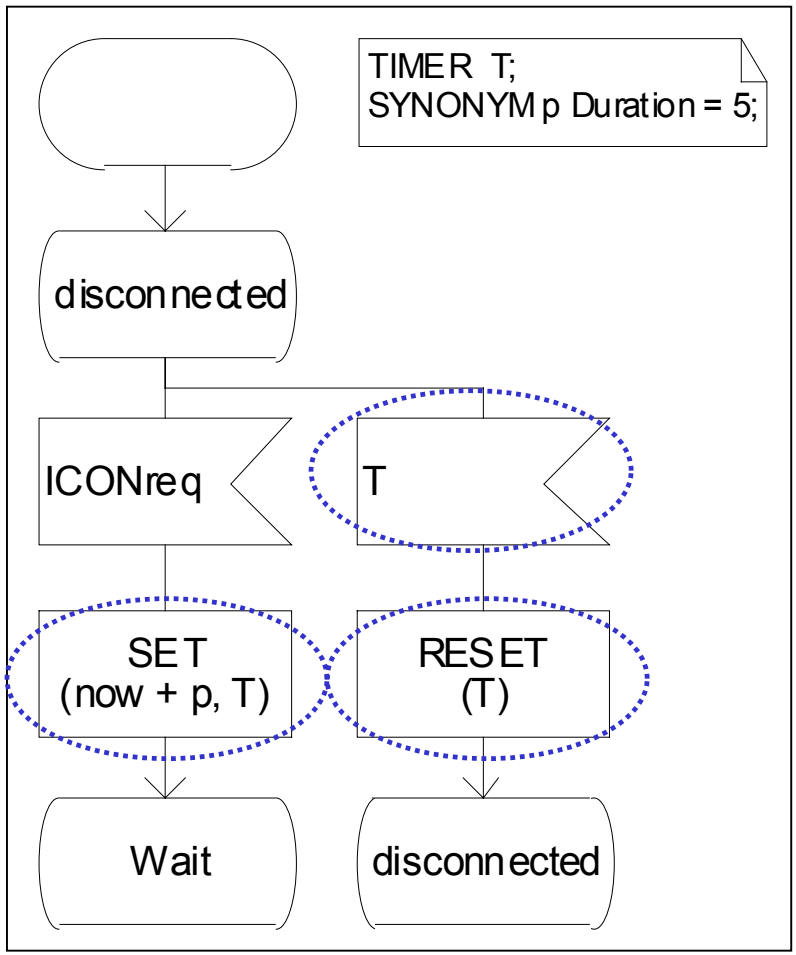
struct in C

```
newtype Connect_Type
   literals type_802_11_a,
            type_802_11_b,
            type_802_11_g;
endnewtype Connect_Type;

newtype Con_Req_Arg struct
  con_type Connect_Type;
  id Character;
  timing Integer;
endnewtype Con_Req_Arg;
```

struct in SDL

Timer

- **On timeout, a signal is sent to the process instance that set the timer.**



- **SET**:
  - Start a timer with time value
- **RESET**:
  - The associated time value is lost
  - Corresponding signal in the input port is removed

Generator

- **The Generator is like the "template" in C++**

```
NEWTYPE int_set
LITERALS empty_int_set;
OPERATORS
      add:     int_set, Integer -> int_set;
      is_in:   int_set, Integer -> Boolean;
AXIOMS
FOR ALL m, n IN Integer, s IN int_set
      ……...
ENDNEWTYPE:
```

```
NEWTYPE real_set
LITERALS empty_real_set;
OPERATORS
      add:      real_set, Integer -> real_set;
      is_in:    real_set, Integer -> Boolean;
AXIOMS
FOR ALL m, n IN Integer, s IN real_set
      ……...
ENDNEWTYPE;
```

```
GENERATOR set
   (TYPE element, LITERALS empty_set)
LITERALS empty_set;
OPERATORS
      add:     set, element -> set;
      is_in:   set, element -> Boolean;
AXIOMS
FOR ALL m, n IN element, s IN set
      …….
ENDGENERATOR;
```

```
NEWTYPE int_set set (Integer, empty_int_set)
ENDNEWTYPE;
NEWTYPE real_set set (real, empty_real_set)
ENDNEWTYPE;
```

Array

- **Array is the predefined generator.**
  - -- *GENERATOR Array(TYPE Index, TYPE Itemsort);*

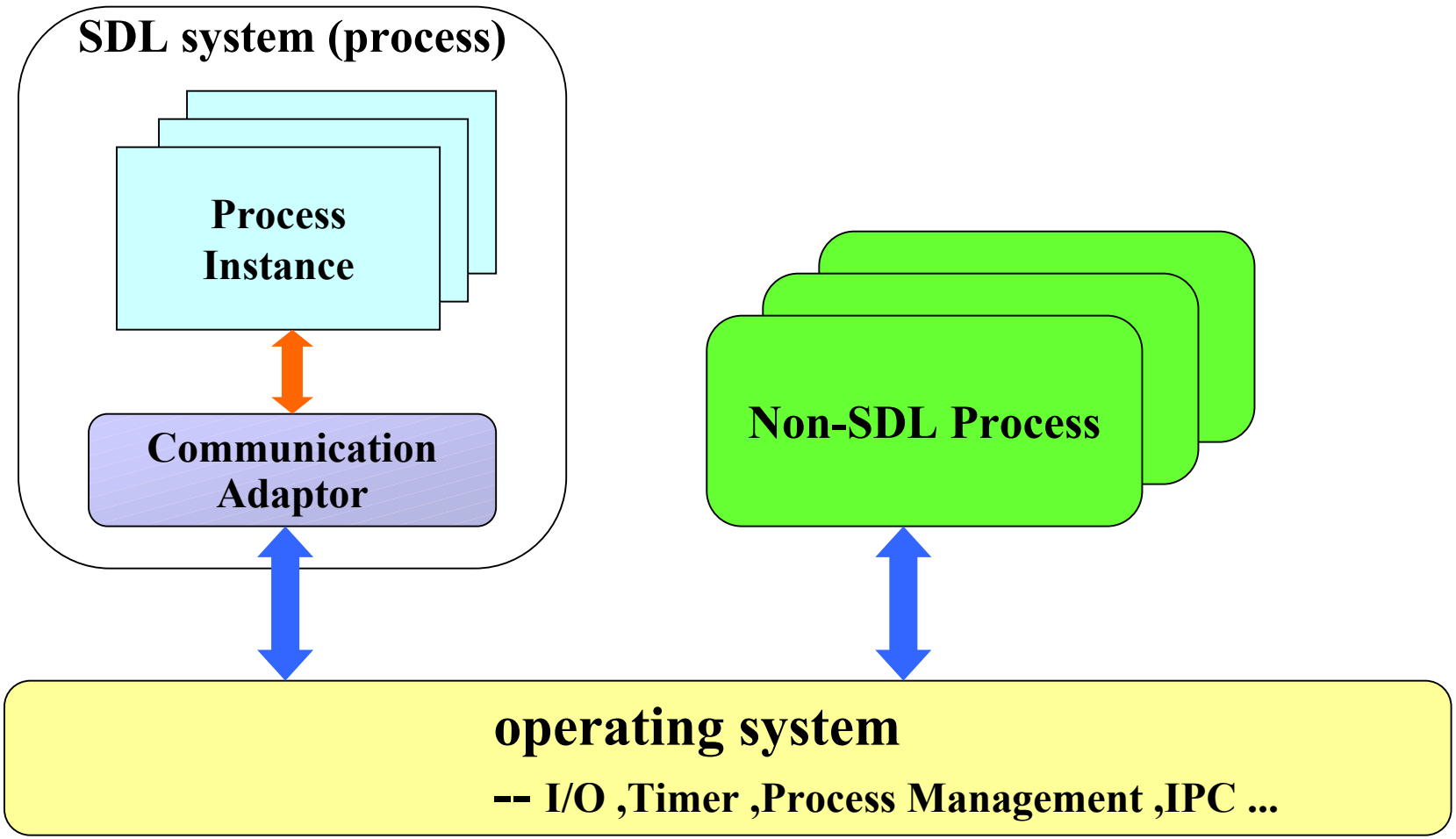
```
SYNTYPE IndexType = Natural
  CONSTANTS 1:100
ENDSYNTYPE;

NEWTYPE Person STRUCT
  theName Charstring;
  theAge Age;
  theEyeColor EyeColorType;
ENDNEWTYPE Person;

NEWTYPE PArrayType
  Array (IndexType, Person)
ENDNEWTYPE PArrayType;
```

```
DCL PersonArray PArrayType;
```

```
PersonArray(2):= (. 'John', 26, Blue .)
```

System Integration (i)

- ***Light Integration***



System Integration (ii)

- ***Tight Integration***