



# Problem-oriented Real-Time Programming of Embedded Systems with PEARL 90

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## ◆ Standards

- DIN 66253-2: PEARL 90

<http://www.din.de>

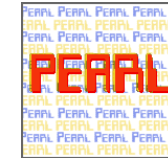
( English Language Report:

<ftp://ftp.irt.uni-hannover.de/pub/pearl/report.pdf> )

- DIN 66253-3: PEARL for Distributed Systems

# 1. Activities / Education

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## ◆ Activities

- DIN NI - 22 Programming Languages
  - NI-22.01: PEARL
- GI FG 4.4.2 Real-time Programming, PEARL
  - <http://www.real-time.de>
  - AK5: PEARL in Education & PEARL Language Support

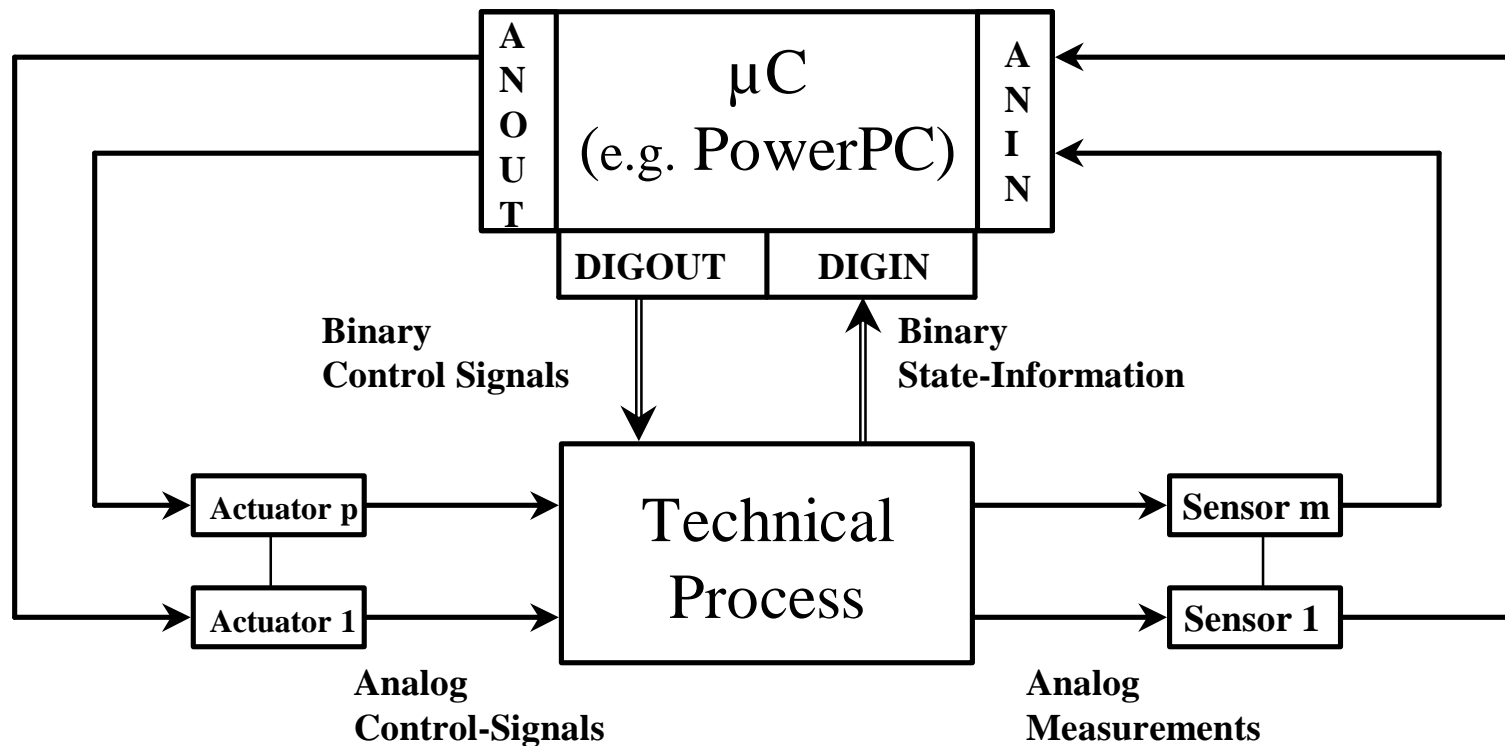
## ◆ Education

> 40 universities and polytechs in  
Germany and Europe (USA ?, Africa ?, China ?)

## 2. Objective of PEARL

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*Fig.1: Typical Specification of a Process-Control / Embedded-Systems Problem*



## *2. Objective of PEARL*

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### **PEARL 90**

*Process and Experiment Automation Realtime Language*

- ◆ **Control & Embedded Systems Applications**
- ◆ **From Engineers for Engineers: *Problem-Orientation***
- ◆ **Low Complexity: *Safety-Orientation***

*Problem-oriented Embedded Systems Automation  
Realtime Language*

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### *3. Structured Programming in the Large*

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#### ◆ **MODULES**

- Data-Structures
- Real-Time Objects ( Implicit Real-Time Classes )
- PROCEDURES
- TASKs

#### ◆ **Relations between Modules**

- Import & Export Interfaces
- Interface to Other Languages (e.g. C ): Module-Level

#### ◆ **Low Complexity**

- No Modules in Modules

## *4. Structured Programming in the Small*

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### ◆ **Low Complexity**

- Implicit Real-Time Classes:

**CLOCK, DURATION**

**SEMAPHOR, BOLT**

**DATION**

**INTERRUPT**

**SIGNAL (EXCEPTION)**

- Problem-oriented Use of Object-Methods
  - Problem-oriented Task Construct & Scheduling
  
  - No Tasks in Tasks
  - No Tasks in Procedures
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## 4. Structured Programming in the Small

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### ■ Problem-oriented Use of Object-Methods: **Process I/O**

- Dation - Object: **Sensor1**

*Direct Use:* Measurement := Sensor1.TAKE;

*Problem-oriented:* **TAKE** Measurement **FROM** Sensor1;

- Dation - Object: **Actuator2**

*Direct Use:* Actuator2.SEND (ControlSignal);

*Problem-oriented:* **SEND** ControlSignal **TO** Actuator2;

## 4. Structured Programming in the Small

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### ■ Problem-oriented Task Construct & Scheduling

- *Task Construct: No Explicit Task Delay-Management*

Controller1: **TASK** ;

**TAKE** Measurement **FROM** Sensor1 ;

    PID (Measurement, . . . ,ControlSignal) ;

**SEND** ControlSignal **TO** Actuator2 ;

**END**;

- *Explicit Task-Scheduling of Periodic Tasks:*

**ALL** Ta **ACTIVATE** Controller1 **PRIO** 10 ;

( *Sporadic Tasks:*

**WHEN** ProcessEvent **ACTIVATE** SequenceContoller ; )

### ◆ **Availability**

- Embedded Systems of **Highest Reactivity:**

*RTOS-UH on PowerPC* (→ [Presentation](#))

- **Large Spectrum** of RTOS:

HP-UX, HP-RT, AIX, OS/2, LynxOS, WindowsNT,  
pSOS+, PXROS, VRTX, Solaris

- **Public Domain:**

PEARL on *Linux* (→ [Presentation](#))

## 6. Real-Time Performance: RTOS-UH

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	MC 68040 25 MHz	PowerPC MPC 604 100 (200) MHz
Clock-Resolution	1 ms	0.1 ms
Reactivity	33 $\mu$ s	7 (3) $\mu$ s
RTOS-UH-Nucleus	11 KB	22 KB

### ◆ **Applications**

- Medical Systems
- Industrial Cranes
- Washing Machine Production
- Drive Control, Mechatronics
- Robotics

- ◆ Reliability- / Dependability- / Safety- oriented  
Software for **Embedded Systems**

- Fault Avoidance & Removal: *Verifiability*
- SW-Fault Tolerance\*: *SW - Diversity*
- SW Fault-Tolerance\*: *Graceful Degradation*

\*L. Pullum: Software Fault Tolerance, 1999 Annual Reliability and Maintainability Symposium: Tutorial Notes

- ◆ **Measures for Fault-Tolerance (FT) & Safety**  
(IEC 61508: Safety Integrity Levels **SIL 1-4** )
  - FT Real-Time Construct Extensions: *HI-PEARL*
  - FT Small Scale Embedded PLC-Systems: *Software-PLC*
    - **Function-Block-Diagram-Language** (IEC 61131-3) *on PEARL: PEARL-PLC, incl. Fuzzy-Control (Verifiability)*
    - **Task & Functionblock - Level Fault-Tolerance:**  
*e.g. Task-Deadline Violation, CAN-Bus Sensor Timeout (SW FT)*