Very Lightweight Agents for Reactive, Fault-Tolerant Real-Time Systems

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Keywords for Motivation

- Large-scale

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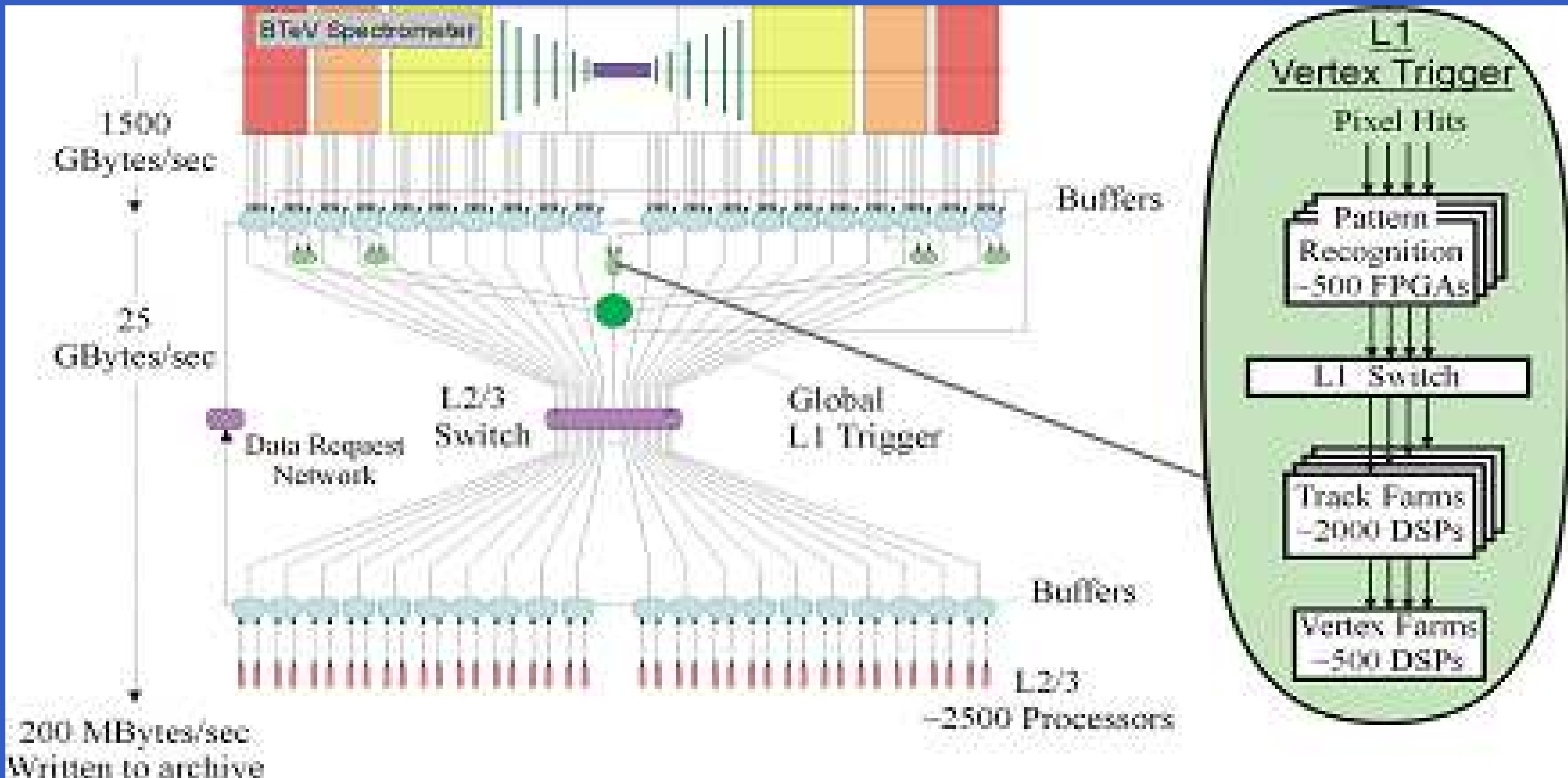
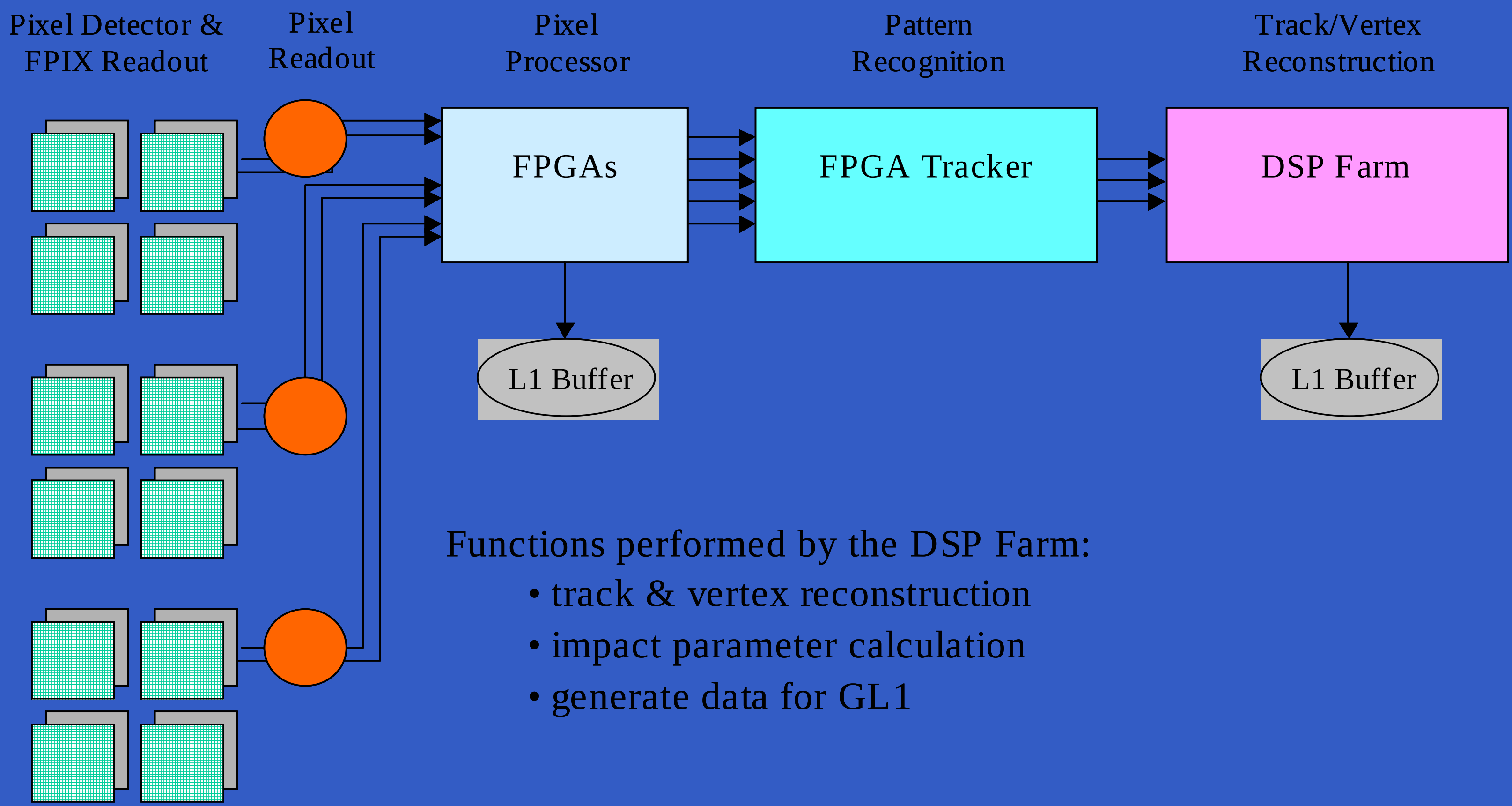
- Intelligent

BTeV triggering and data acquisition s



Level 1 Pixel Trigger



Functions performed by the DSP Farm:

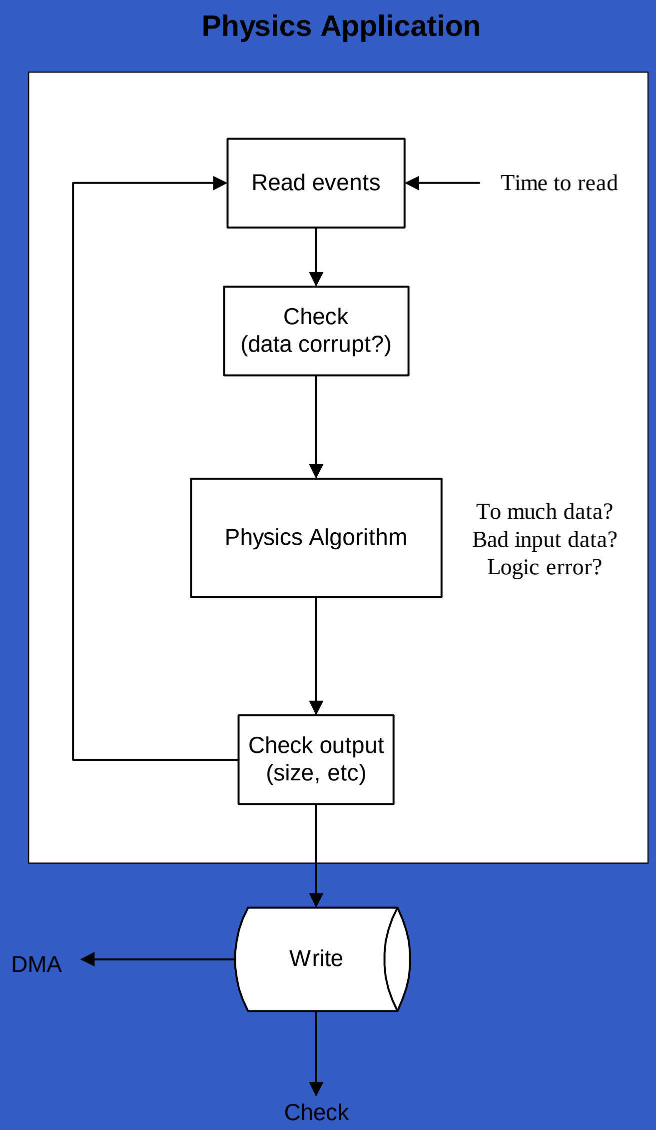
- track & vertex reconstruction
- impact parameter calculation
- generate data for GL1

Figure 0: Adopted from BTeV-doc-308-v1 (Gottschalk)

BTeV triggering and data acquisition s

- About 2,500 DSPs (L1)
  - Fast data aquisition
  - Fault monitoring
  - Fault-tolerant
  - Adaptive to failure
  - Run physics applications

Event-loop of a physics application



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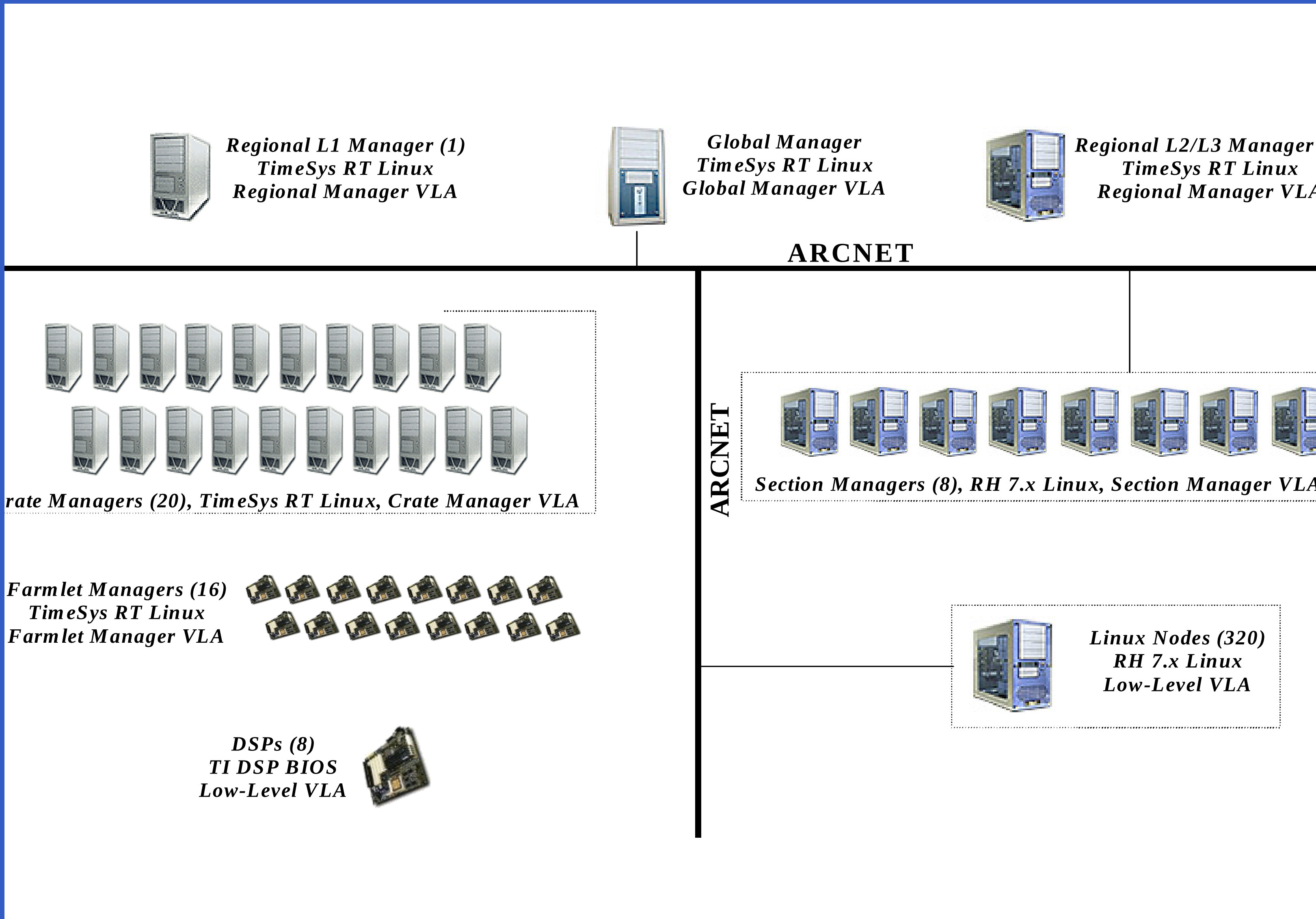
- Hierarchical

Envisioned VLA hierarchy (Prelimiar



VLA design theoretical background

- Brooks' subsumption architecture
- designed for robot controls
- Small reactive Augumented Finite State Machines – no full-blown explict k nowledge representaion
- Higer level "subsumes" lower level control when appropriate

VLA theoretical background (cont.)

- Intelligence “emerges” when simple components interact
- BTeV/RTES deals with real hardware components (robot control systems too)
- Realtime managements, Fault-tolerant, small footprint, fast, adaptability

Rule subsumption

```
Function action (p:  P): A
var fired:  P(R)
var selected :  A
begin
   fired := {(c,a)|(c,a) ∈ R and p ∈ c }
   for each (c,a) ∈ fired do
      if ¬(∃(c′,a′) ∈ fired such that (c′,a′) ≺ (c,a) then
         return a
      end-if
   end-for
   return null
end function action
```

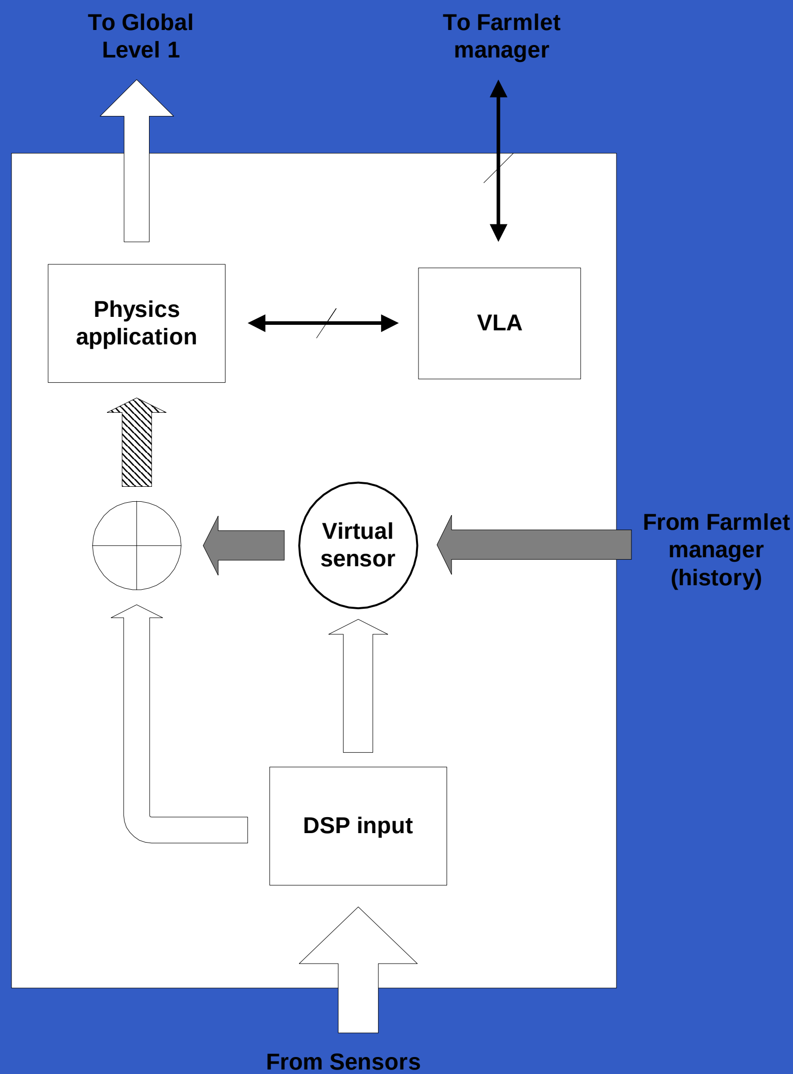
Suggested Modifications to the SA

- The division between layers is too rigid: let layers to be able to communicate if needed while keeping the communication traffic minimal.
- Allow blackboard architecture: VLAs can communicate via this facility.
- Introduce proactivness in the subsumption architecture.
- Inter-VLA subsumption and Intra-VLA subsumption: hierarchy of VLAs

The notion of virtual sensors

- When a hardware sensor fails, a virtual sensor can act
- Temporary feed from history (extraploation)
- Temporary feed from near by sensors
- Usefulness in the RTES environment – yet to be determined

Virtual sensor with VLA



Subsumption Rules for Farmlet VLAs

FR1 Condition: no communication with a L1-level VLA for a certain period of time. Possible causes: The DSP may be down; Com-link may be down; The DSP may be overloaded. Actions: Ping the DSP; reset the DSP; reboot the DSP.

FR2 Condition: I/O error or File I/O error when accessing a history file. Possible causes: File doesn't exist; Disk full Invalid file pointer; Communication problem with a file server. Actions: Notify higher level entities including human operator.

FR3 Condition: the first start-up after a power loss. Actions: Perform data and hardware integrity tests.

FR4 Condition: Received data integrity problem notification from a lower level VLA. Actions: Find the hardware that causes problem; Activate the virtual sensor and channel history data to the virtual sensor, if appropriate.

FR5 Condition: The Farmlet CPU utilization drops below a certain level. Action: Run additional diagnostic procedure, communicate with other VLAs, perform preventive actions, and check not-so-critical conditions.

FR6 Condition: Timer interrupt for periodic checking is received. Action: Perform the required procedure.

Priority $FR3 \prec FR1 \prec FR4 \prec FR2 \prec FR6 \prec FR5$.

Rules for L1 level VLAs

- L1R1 Condition: Event data corrupted. Action: report to the Farmlet manager. Check hardware.
- L1R2 Condition: Too much event data. Actions: report to Farmlet manager.
- L1R3 Condition: Too little data. Actions: report to Farmlet manager. Note that the Farmlet manager may activate corresponding virtual sensor.
- L1R4 Condition: No input from sensors Actions: report to the Farmlet manager. Test hardware integrity.
- L1R5 Condition: Overloaded DSP. Actions: report to the Farmlet manager.
- L1R6 Condition: Timer interrupt for periodic testing task has been received. Action: Perform the test.
- L1R7 Condition: Certain additional CPU cycles can be spared for the VLA. Action: Run additional diagnostic procedure, communicate with other VLAs, perform preventive actions, check not-so-critical conditions, etc.

Priority $L1R4 \prec L1R5 \prec L1R1 \prec (L1R3 = L1R2) \prec L1R6 \prec L1R7$.


L1R4 : No input from sensors (notified from the physics application. The physics application may not have been able to do anything)--> Report to the Farmlet manager. Test hardware integrity
L1R5: Overloaded DSP --> Report to the Farmlet manager
L1R1 : Event data are corrupted (notified from the physics application) --> Report to the Farmlet manager. Investigate if a hardware problem
L1R3 : Too little data. (notified from the physics application after attempting to extrapolate) --> Report to Farmlet manager
L1R2 : Too much event data (notified from the physics application after throwing away certain percentage of the data)--> Report to Farmlet manager
L1R6 : Timer interrupt for periodic testing task has been received --> Perform the test
L1R7 : Additional CPU cycles can be spared for the VLA --> Run additional diagnostic procedure, check not-so-critical conditions

VLA Prototypes

- Several prototypes built for an experimental DSP board
- Two TI DSPs on board
- Need more DSPs to study interactions among VLAs
- Currently, building VLAs for a DSP board with 8 DSPs.
- Please visit the poster presentation session for details of prototypes

Conclusion

- The BTeV environment calls for fast, fault tolerant, adaptive agents
- Concept of VLA is being investigated
- Based on the subsumption architecture
- Several pre-prototypes have been built (limited rules and actions)