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Xenomai

Hardware

Integration

Qualification

Evaluation  
tools

Conclusion

# Xenomai: integration and qualification of a real time operating system ARMadeus Systems

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Integration

Qualification

Evaluation  
tools

Conclusion

1 Xenomai

2 Hardware

3 Integration of Xenomai in a Buildroot environment

4 Qualification

5 Evaluation tools

6 Conclusion

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Integration

Qualification

Evaluation  
tools

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- Real time extension for Linux.
- Second kernel in charge of real time tasks  
→ *Linux* stays in charge of shared time applications
- Keep existing working environment and applications
- Easy port of applications to a real time environment

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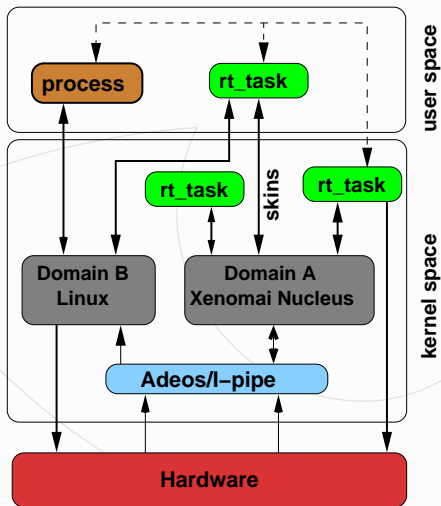
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- Adeos
- Xenomai
  - concurrent access to hardware
  - software cooperative with *Linux*
  - easy port of applications



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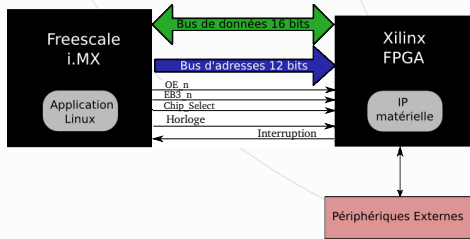
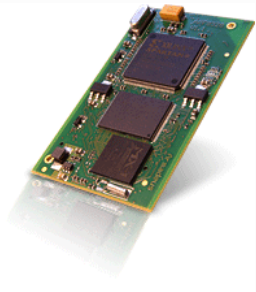
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*APF9328* board:

- based on a Freescale i.MX CPU providing an ARM9 core
- 16 MB RAM
- Xilinx Spartan 3 FPGA shares data, address and control busses with the CPU



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No packages for *Xenomai* in *Buildroot* framework

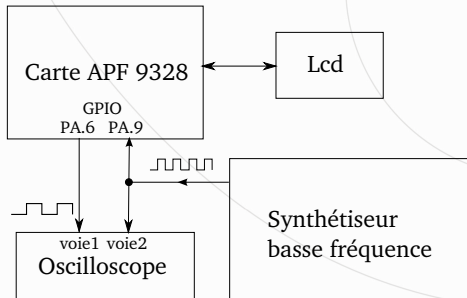
- manual install
  - Patch:
    - *Ipipe* provided by *Adeos*
    - Xenomai applied to Linux by *prepare\_kernel*
  - Configure and compile kernel
  - Compile and install libraries in user space

**Complex and time consuming**

- Automated install
  - Interaction with the kernel
  - Libraries

**Xenomai installs immediately**

- Objective:  
monitor the performances of applications.
- Concept:  
generate signals using dedicated hardware (synthesizer) and display the results on a digital storagescope.
- An application loads the system to disturb the periodic phenomenon



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Two kinds of behaviours are observed:

- Periodic timer handling
- Hardware interrupt servicing

Exemples are tested in user space and kernel space, *Linux* and *Xenomai*.



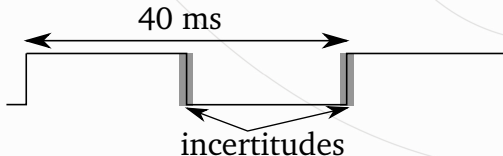
- Linux
  - declare a handler:
 

```
sa.sa_handler = isr;
sigaction (SIGVTARLM, &sa, NULL);
```
  - trigger the counter:
 

```
setitimer (ITIMER_VIRTUAL, &timer, NULL);
```
- Xenomai
  - configure the counter:
 

```
rt_task_set_periodic (NULL, TM_NOW,SLEEP);
```
  - wait:
 

```
rt_task_wait_period (NULL);
```



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# Results: periodic timer in user space

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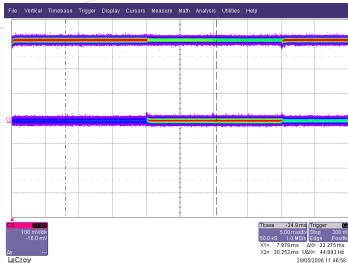
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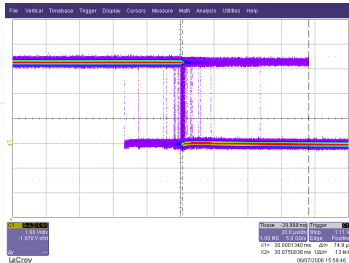
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(a) Linux, 5ms/div



(b) Xenomai, 20µs/div

	<i>Linux</i>	<i>Xenomai</i>
min	?	-32
max	?	+74,9

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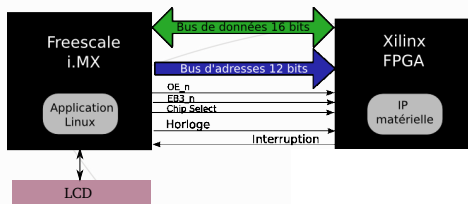
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Conclusion

- *Xenomai* available on an *ARM9* architecture
- Better global performances on a weakly loaded *OS*
- Better tolerance to loading
- Expensive tools, hardly convenient and not always suitable:
  - 2 GS/s digital storagescope  $\Rightarrow$  40.000 euros.
  - Connect *GPIO* outputs
  - Results are not always usable (counter on Linux).

Purpose:

- no additional hardware
- no changes to the kernel



Principle:

- use the FPGA
- able to measure performances of several codes at a given time
- usable in user space and kernel space under *Linux* and *Xenomai*.

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- VHDL components:
  - acquire and store measurements
  - generate signals
- kernel module:
  - configure IPs.
  - transfer (read) acquired data
- MACROS:
  - atomic
  - usable in user space and kernel space
  - can be disabled

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- Multiple measurements
- Compatible with data transfer on a *Wishbone* bus
- Uses *POD*

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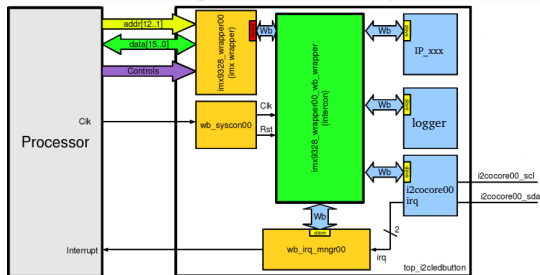
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Evaluation  
tools

Conclusion



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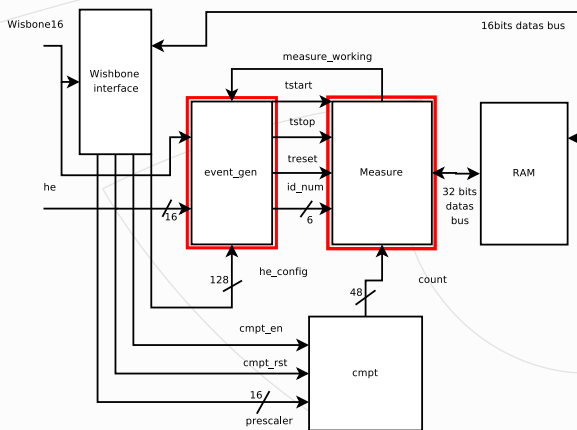
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Qualification

Evaluation  
tools

Conclusion



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Qualification

Evaluation  
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Conclusion

Replaces the oscilloscope.

Computes and stores the time differences between *start* and *stop* events

- Store the current counter value
- START
- STOP
- RESET



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Qualification

Evaluation  
tools

Conclusion

Replaces the oscilloscope.

Computes and stores the time differences between *start* and *stop* events

- START
- STOP
- RESET
- recover the starting value
- comparison with the current value
- increase cycle number
- update min
- update max

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Integration

Qualification

Evaluation  
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Conclusion

Replaces the oscilloscope.

Computes and stores the time differences between *start* and *stop* events

- START
- STOP
- RESET
- min
- max
- number of cycles
- duration of the test

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Qualification

Evaluation  
tools

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- Configurable signal generator
- Replaces the dedicated hardware synthesizer
- Interaction with *Measure* and the application

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Evaluation  
tools

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Access:

- */proc/driver*
- */dev*
  - `LOGGER_GET_ID`
  - `LOGGER_MEMBASE`

`/proc/drivers/log`

```

0
├── attr
│   ├── name
│   ├── type
│   └── pid
├── measures
│   ├── min
│   ├── max
│   ├── nb_trig
│   ├── nb_meas
│   └── total_time
├── params
│   ├── trigger
│   ├── ext_start
│   ├── ext_stop
│   └── reset
├── clock
├── start
├── stop
├── add
├── del
└── prescaler
  
```

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Known and deterministic access time  $\Rightarrow$  memory mapped data transfers

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Evaluation  
tools

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- *CREATE\_ALL(nom)*
- *OPEN\_LOGGER*
- *FPGA\_START(nom)*
- *FPGA\_STOP(nom)*

```
...  
int main(void) {  
    OPEN_LOGGER();  
    CREATE_ALL(foo);  
    ...  
    FPGA_START(foo);  
    // Code a tester  
    FPGA_STOP(foo);  
    ...  
}
```

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- Autonomous
- Simple to use
- Quantitative data

	oscilloscope		tool	
	min	max	min	max
<i>Linux</i>	?	?	-1540	42439
<i>Xenomai</i>	-32	+74,9	-25	100

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Evaluation  
tools

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- *Xenomai Buildroot Package* available
- *Xenomai* runs on *APF9328*.
- Embedded evaluation tools for quantitative analysis of applications and kernel modules

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Evaluation  
tools

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# questions ?

<http://www.armadeus.org>

<http://sourceforge.net/projects/periphondemand>