Towards a Reactive Model for the Power-Aware Control of an Embedded Platform

(Work in progress. . .)

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Outline

- Context
  - Target platforms & applications
  - Problems
- Current solutions
  - Ad-Hoc solutions
  - Dedicated Operating Systems
  - Conclusion
- Approach
  - Preliminary remarks
  - Principles
  - Pros & Cons
- Conclusion

Outline

Target platforms

- μ-Controller
  - Sleep/low-power modes and fast wake-up time
  - Possibly DV(F)S capable
- Radio transceiver
- Real-time clock
- Sensors (Temperature, Humidity. . .)
- Battery-operated
  - Possibly solar-reloadable
- . . .

Target platforms (contd.)

Energy *vs.* Power

- Energy-awareness: control *average* current consumption
  - related to discharge profile
- Power-awareness: control *maximum* current consumption
  Highly related to:
  - capacity
  - quality ($\leadsto$ cost)

Target applications

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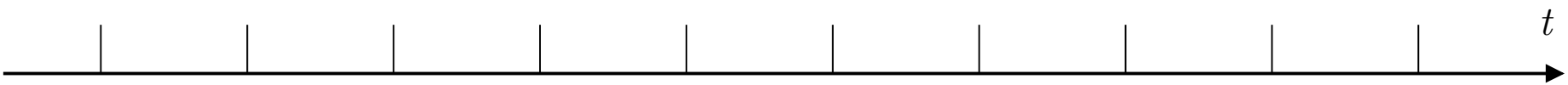

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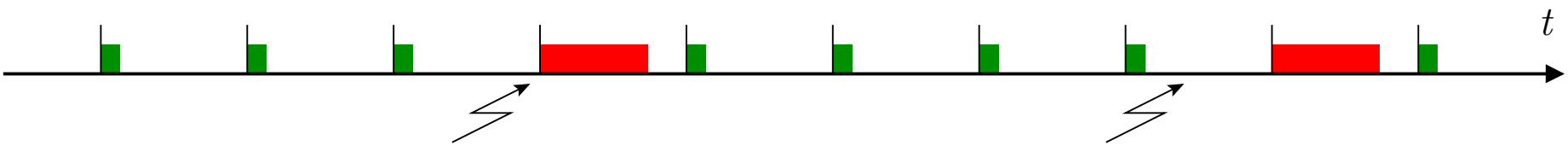

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Problems: distribution

- "Chaotic" global behavior, dynamism
- Debugging
- Shelf life
- Unreliable communications
- Security
- ...

worse and worse...

Problems: “embeddedness”

- Cyber-physical device: closed loop (reliable simulation...?)
- Various constraints
  - low speed
  - very small memory
  - ...
- Various peripherals
- ...

Outline

Current solutions: ad-hoc solutions

Manual implementation

- Method?
- Toolchain?
- Power management?
- ...
- Reliability?

Current solutions: dedicated Operating Systems

TinyOS

- Event-driven paradigm
- All implemented in nesC
  - restricted / extended C
  - fully component-based approach
- Compiled together with the applications
- Locks $\rightsquigarrow$ deadlocks
- Power management: manual & decentralized
- Available on many platforms

$\rightsquigarrow$ tens of components needed for simple applications...

Current solutions: dedicated Operating Systems (contd.)

MANTIS

- Classical programming model
- Supports long-running computations
- Power management by hand

$\rightsquigarrow$ More efficient than TinyOS when:

- long idle periods
- timely processing

Current solutions: dedicated Operating Systems (contd.)

Contiki

- *Exokernel*
  - tries to reduce provided abstractions
  - instead: use libraries
- *Proto-threads*
  - event-based, stack-less
  - optional preemptive multi-threading implemented as a library
- Inter-process communication: *event posting*
- Power-management by hand (only helped by exposing the size of the event queue!)

Context: conclusion

$\Rightarrow$ *No mechanism allowing global management of the platform!*

Outline

Approach: preliminary remarks

- Driver $\approx$ Automaton — In fact, a *Transducer*:
  - Inputs = software requests & hardware interrupts / data
  - Outputs = software responses & hardware requests
  - Reflects the state of the associated device

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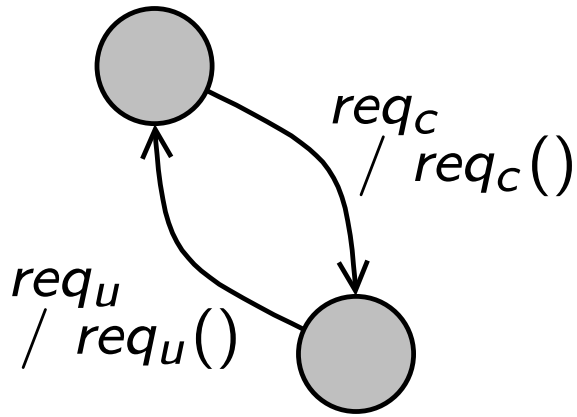
Approach: preliminary remarks (contd.)

Controllable Driver

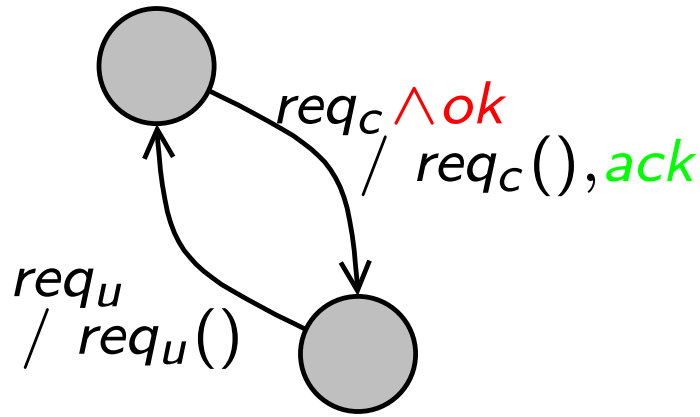
- Inputs: $\{req_c, req_u\}$
- Outputs: $\{req_c(), req_u()\}$



Approach: preliminary remarks (contd.)

Controllable Driver

- Inputs: $\{req_c, req_u, ok\}$
- Outputs: $\{req_c(), req_u(), ack\}$



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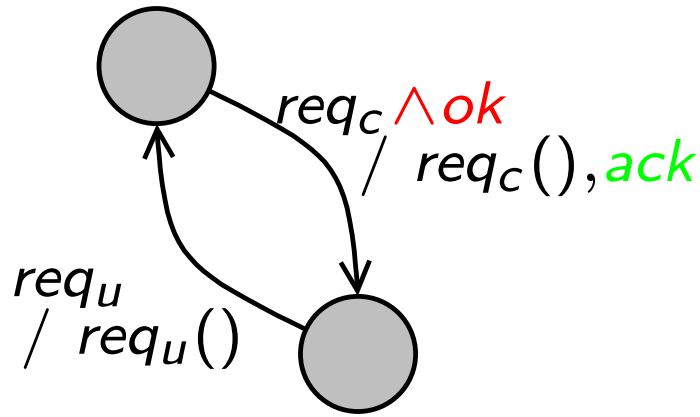
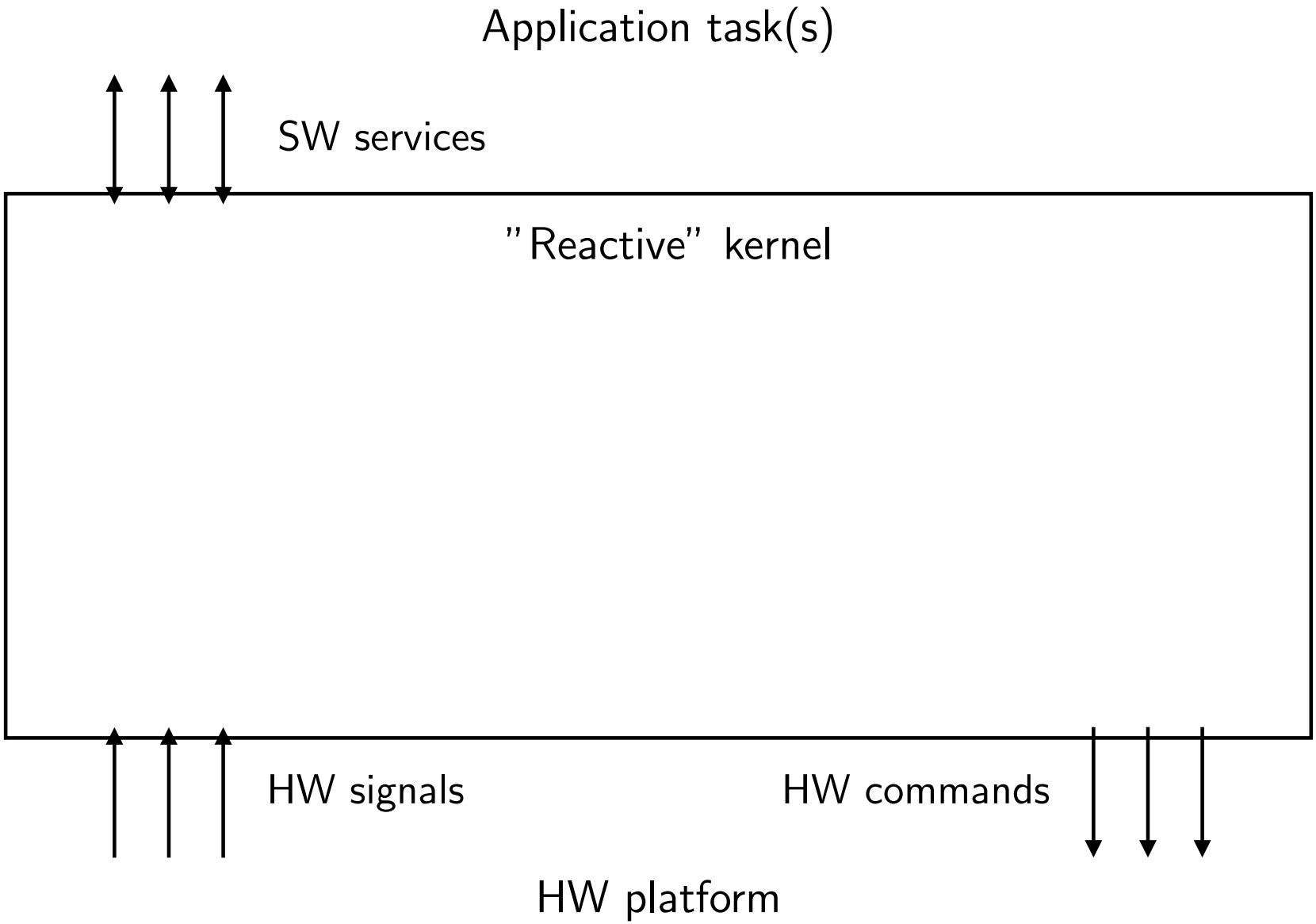


ok: Validation from controller

ack: Refused request handling

Approach: overview



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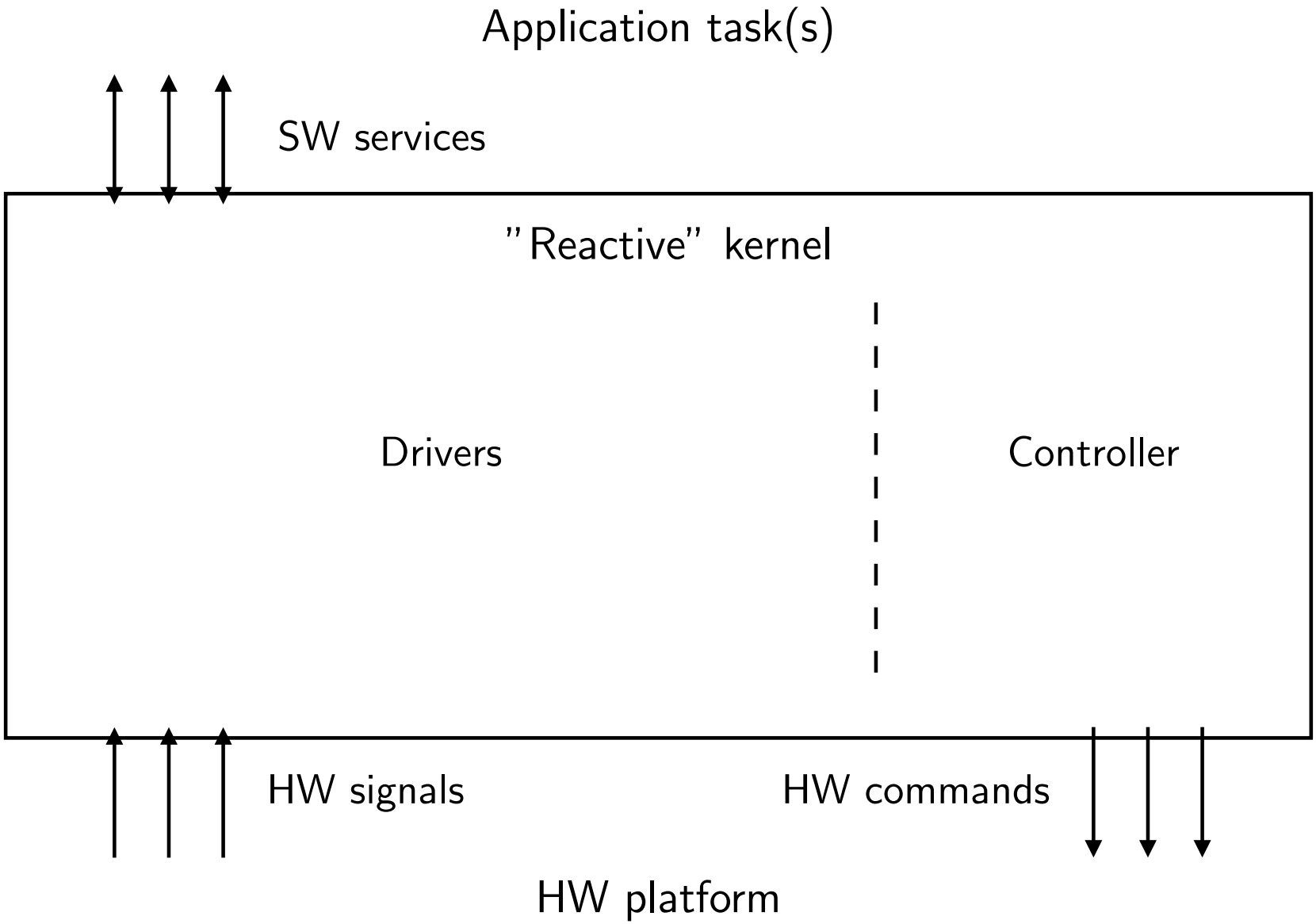

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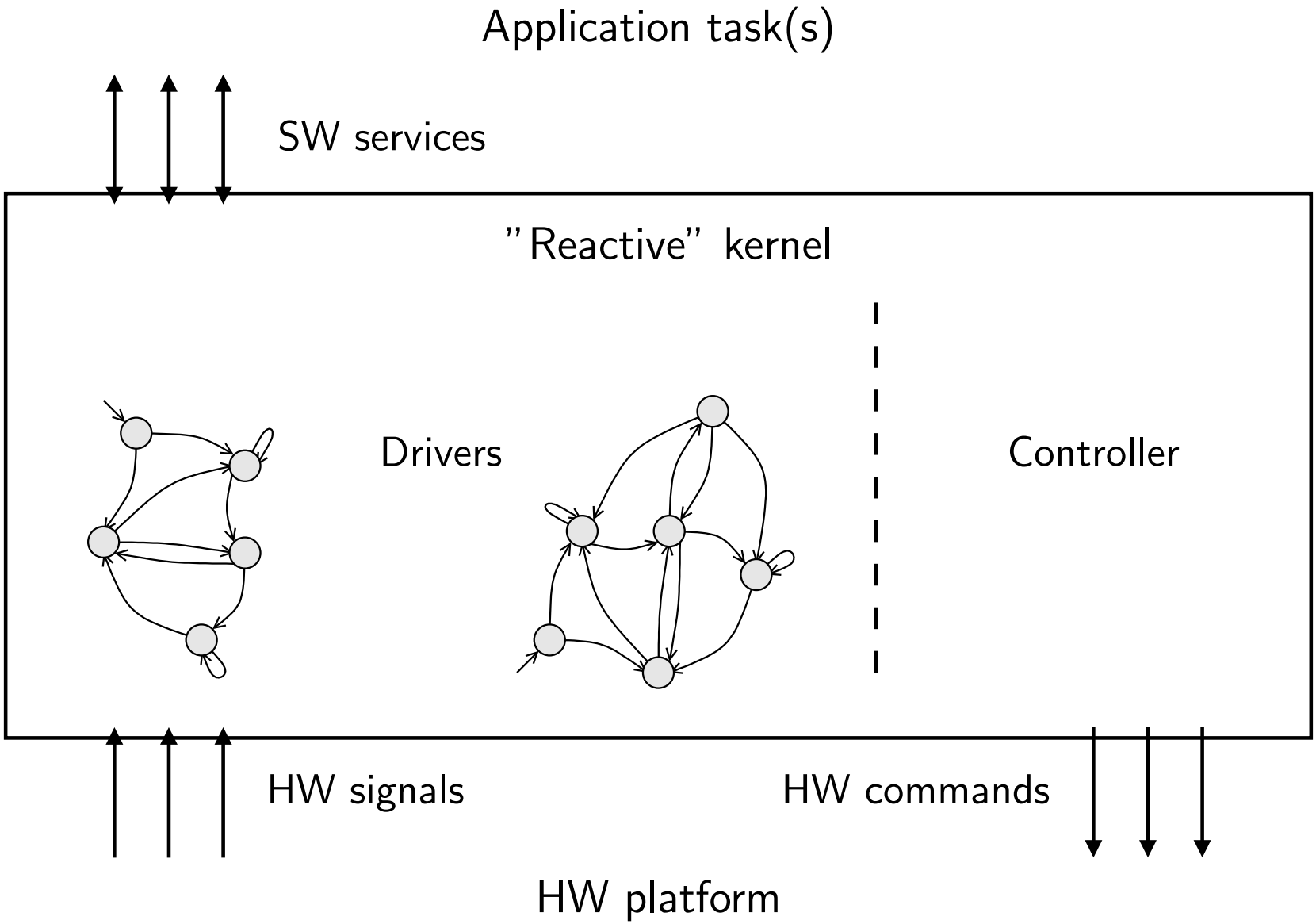

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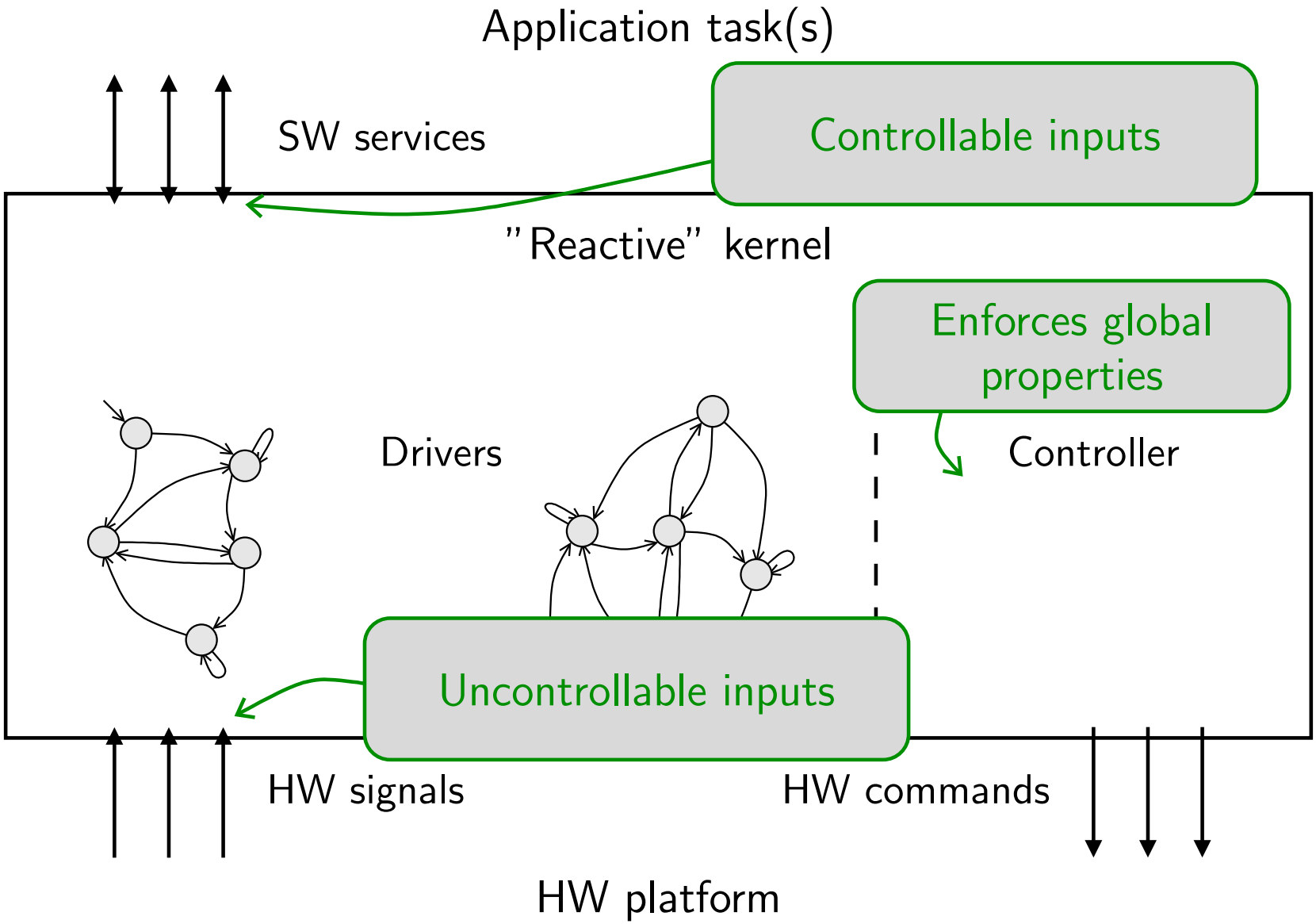
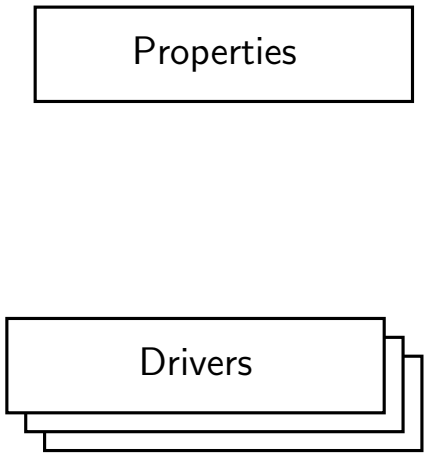


Approach: framework



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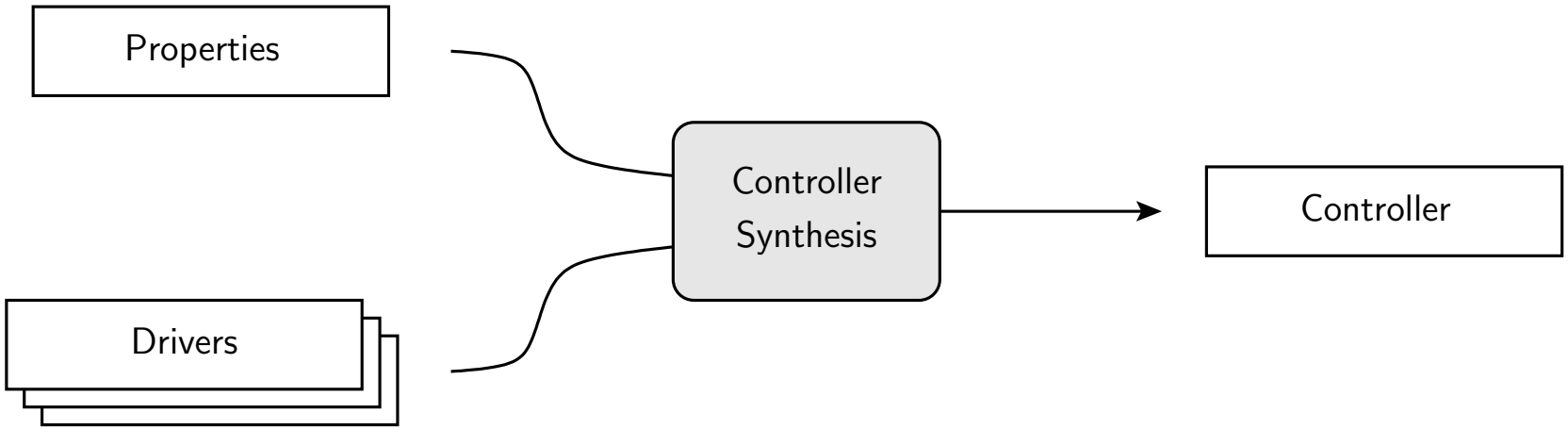

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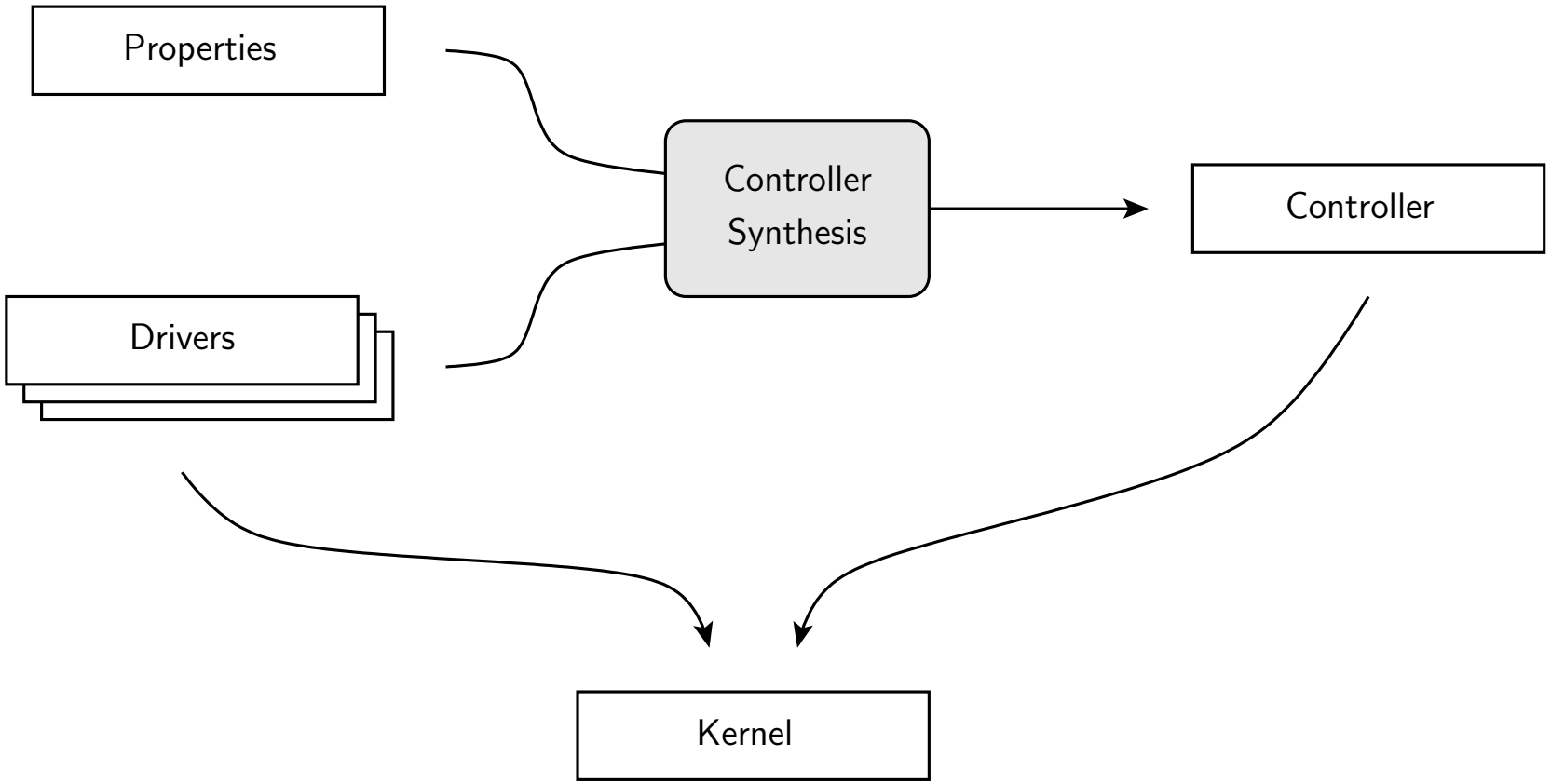

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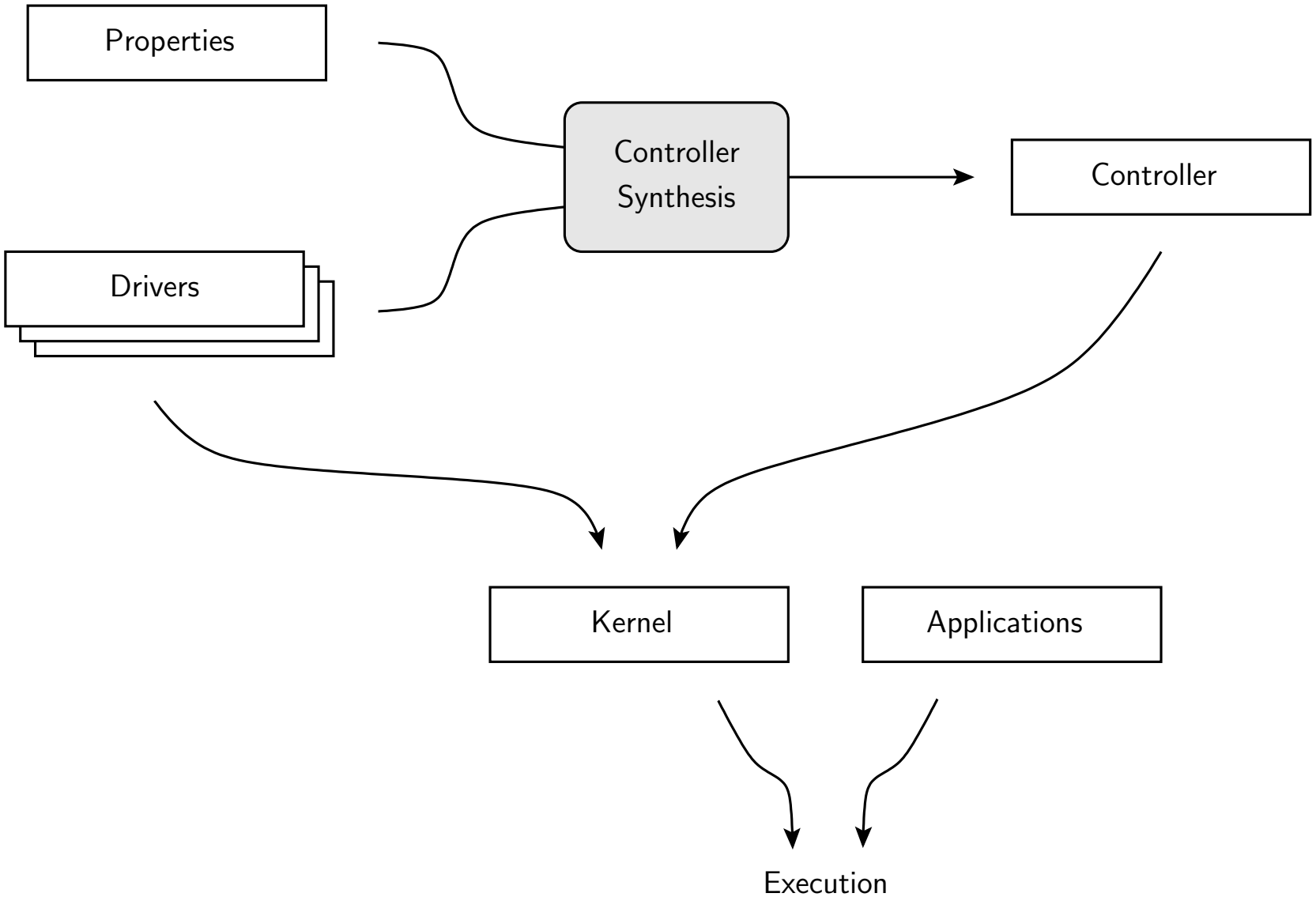

Approach: cons

Cons

- Uncontrollable combinations of platforms & properties
- Very platform-specific properties
- It is still possible to write energy-hungry applications

. . . not surprisingly!

Approach: pros

Pros

- Power & Energy -aware "by construction"
  depending on the properties...
- Unchanged application layer
- Concurrency handling by the controller:
  $\leadsto$ No locks $\Rightarrow$ No deadlocks
- Supports long-running application tasks
  - Classical programming model

Outline

Conclusion

- Lack of global control capabilities in current tool-sets
  - Most often too hard to implement
- Global control of the platform
  - Concurency handling
  - Power & Energy management
- Towards a "Real-Energy Programming" paradigm
- Proof-of-concept implementation (in progress)
  - Realistic application

Thank you

Questions ?