TinyGALS: A Programming Model for Event-Driven Embedded Systems

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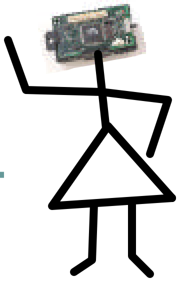

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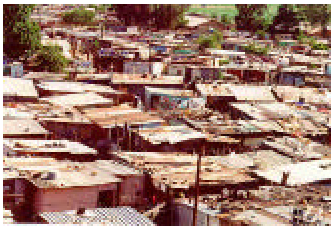
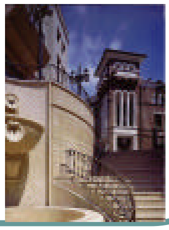
Introduction



- Embedded software architecture ***today***
  - Inherited from writing device drivers and optimizing assembly code.
  - Poor scalability.
  - Poor common infrastructure.
  - Poor resource management.

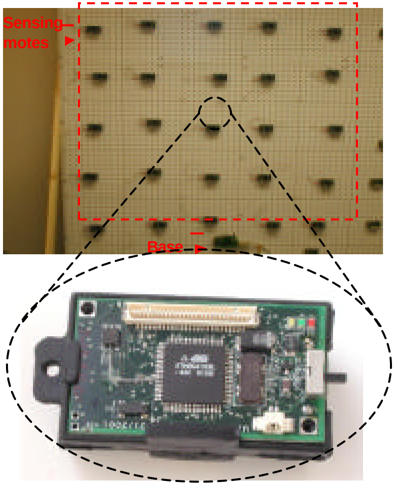
- Embedded software architecture ***tomorrow***
  - Reusable, reconfigurable components.
  - Easy to use.
  - Fast prototyping.
  - Software synthesis



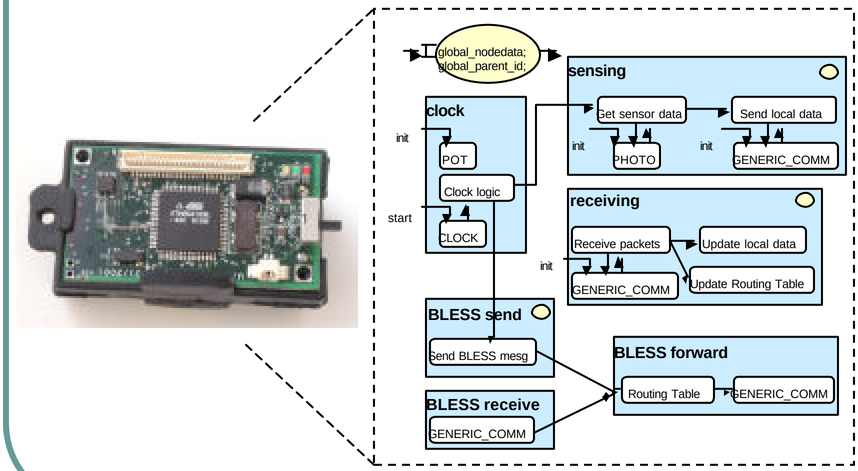
Motivation

- Application characteristics
  - Ad-hoc networked embedded systems
  - Low-power
  - Unstructured, unsynchronized events
  - Collaborative nodes
    - Local communication (peer-to-peer)
    - Global communication (ad-hoc routing)

Example: Sensor Networks



TinyGALS



global_nodedata;
global_parent_id;

clock
init
POT
Clock logic
start
CLOCK

sensing
Get sensor data
Send local data
init
PHOTO
init
GENERIC_COMM

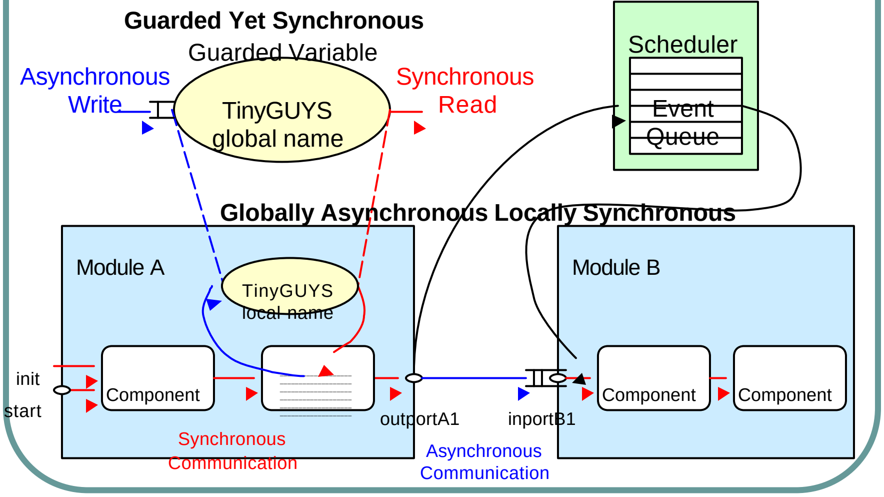
receiving
Receive packets
Update local data
init
GENERIC_COMM
Update Routing Table

BLESS send
Send BLESS mesg

BLESS forward
Routing Table
GENERIC_COMM

BLESS receive
GENERIC_COMM

TinyGALS Architecture



Guarded Yet Synchronous

Guarded Variable

Asynchronous Write

TinyGUYS global name

Synchronous Read

Scheduler

Event Queue

Globally Asynchronous Locally Synchronous

Module A

TinyGUYS local name

init

start

Component

outportA1

inportB1

Module B

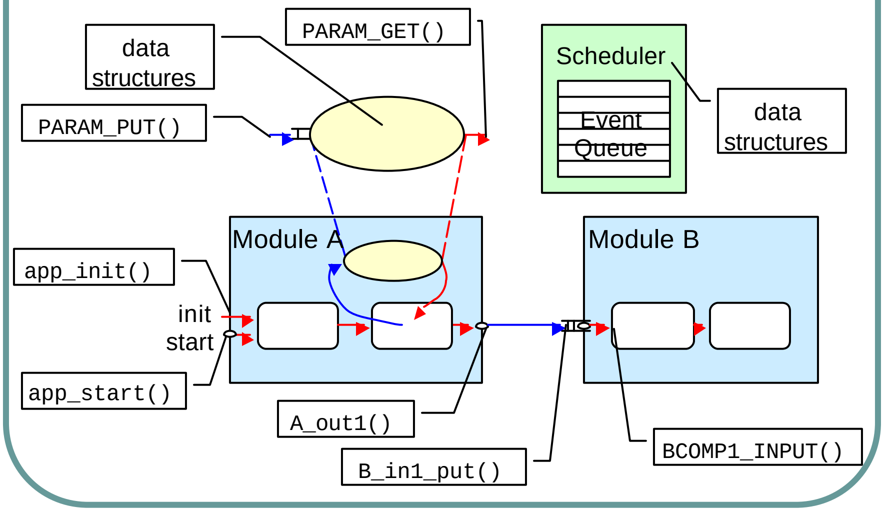
Component

Component

Synchronous Communication

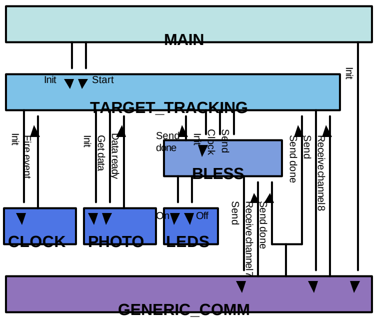
Asynchronous Communication

Software Synthesis

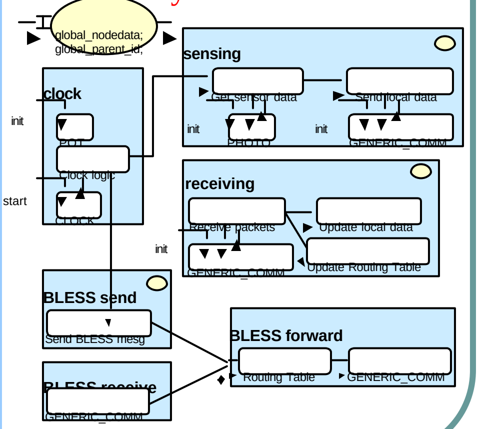


Target Tracking Example: Before and After…

OS View (TinyOS)



TinyGALS View



Memory Usage

Scheduler code size	
TinyOS	TinyGALS
86 bytes	112 bytes

Sizes of generated functions (bytes)	
app_init()	58
app_start()	6
A_out()	12
B_in_put()	160
BCOMP1_FIRE()	98
A_param_PARAM_GET()	10
A_param_PARAM_PUT()	16

Sizes of generated variables (bytes)	
eventqueue_head	2
params	2
entrypoints	2
eventqueue_count	2
eventqueue	100
ports	104
params_buffer_flag	1
params_buffer	2

Conclusions

- TinyGALS provides a globally asynchronous, locally synchronous model of computation for event-driven embedded software.
- Allows reuse of software components.
- TinyGUYS provides protected, quick access to global data.
- Software synthesis tools created to generate communication and scheduling code.

Future Work

- Blocking write: retry when queue is full.
- Priority scheduling algorithm with queue insertions.
- Run-time reconfigurability of modules.
- Heterarchy: distributed multi-tasking.