Fawkes at a Glance

Introduction to the Fawkes Robot Software Framework

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1. Retrospective
2. Design Goals
3. Components
4. Development
5. Loose Ends

1 Retrospective
- RCSoft Drawbacks
- RCSoft Benefits

2 Design Goals

3 Components

4 Development

5 Loose Ends

Code Management Flaws

- CVS hackery took place
- Many dependencies
- External libs inside the source tree
- Dependencies not documented and even somewhat hidden
- Inefficient build system with long build times and huge Makefiles

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All of these problems can be fixed inside RCSoft itself with some effort.

Error Inducing Problems

- Hard to debug with gdb (signal pollution)
- Code polluted (i.e. two approaches in BB)
- No detection of multiple module instances or BB writers
- Overhead due to process switches
- Insufficient config system (no long-time storage)
- Parameters unknown or even “working against each other”
- No central logging, just logging transferred data that made it through the network

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Besides GDB problem this can be fixed inside RCSoft with a re-factoring, cleanup and fixing development cycle.

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- Global storage locking
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Influenced by hardware performance. No easy way of fixing these problems inside RCSoft.

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- No synchronization
- No information about data age
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RCSoft probably wastes a lot of time calculating data twice before it is actually used. No information available about program flow. No way to fix this without major changes.

RCSoft’s Good Stuff

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Start over from scratch. Keep the good ideas, improve or replace the not-so-good ones.

1 Retrospective

2 Design Goals
- Masterplan
- Summary

3 Components

4 Development

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What to Keep

- Keep modular structure
- Keep unified information storage (similar to BlackBoard)
- Provide simple templates for new modules
- Provide the well-known tools (RCCC, vis_bb, FireStation)

What to Avoid

- Avoid polling, events and blocked waiting instead
- Avoid dependencies where possible, have few and document them well
- Avoid code duplication and more approaches where useless (different visions, localizations etc. may be OK, having two thread implementations is useless)
- Avoid everything that makes debugging hard or impossible

What to Add and Improve

- Source code management
- Enforce documentation
- Sleek and fast build system
- Easy modular software structure
- Mutual exclusions on information storage
- Throw away stuff not needed any more, it's still in SVN!
- Make it debuggable and do it! (gdb, valgrind, QA apps, unit tests)
- Use exceptions for good error handling and better readability

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- Not met guarantees are crash points by design

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Guarantees are needed to keep the code simple, to have well defined software interfaces and to minimize the risk of errors.

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- *Time Source:* Guarantee that all components use the exact same time source

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One to rule them all: only one dynamic application

1 Retrospective

2 Design Goals

3 Components

- At a Glance
- Libraries
- Infrastructure Components
- Main Application and Plugins
- Aspects

4 Development

5 Loose Ends

Basic Components

Libraries

Basic set of libraries that can be used in Fawkes.

Main Application

Application able to load, init and run Fawkes plugins.

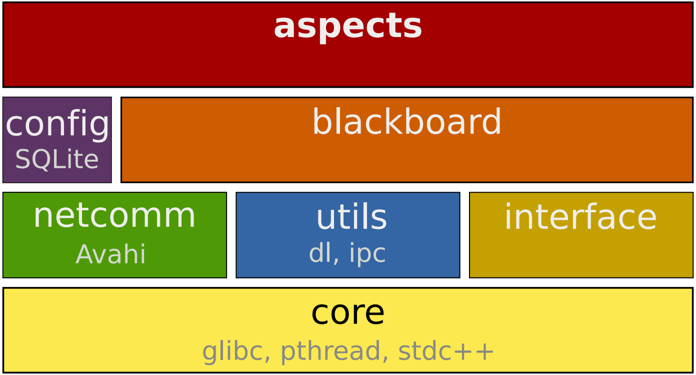
Threads

Everything is a thread. All operations are carried out in a thread.

Plugins

Units containing the real functionality of the robot.

Library Overview



aspects

config
SQLite

blackboard

netcomm
Avahi

utils
dl, ipc

interface

core
glibc, pthread, stdc++

Fawkes Core Library (FCL, core)

- Contains core components, may not depend on other non-system libraries
- Threading API
- Synchronization constructs (mutex, wait condition, read-write lock etc.)
- Exception API
- Plugin API
- Base utils needed in FCL

Fawkes Utilities (utils)

- Resembles old utilities
- May not depend on other non-system libs besides core
- Currently:
  - Logging
  - IPC
  - Plugin loading
  - System
  - Text
  - Time

Network Communication Library (netcomm)

- Socket API
- Fawkes Network Protocol implementation
- Multicast WorldInfo Transceiver
- Robot and service discovery using DNS-based service discovery over multicast DNS (mDNS-SD)

BlackBoard (BB, blackboard)

- Unified and central information storage
- Completely new implementation with similar goals
- Read/write lock per interface
- No more searching, simple pointers, small data blocks (few bytes)
- No multi-process access
- Central logging instance integrated (tbd)
- Possibility to get notified of changes (tbd)
- Guarantees writer singleton

BlackBoard - Interfaces

- Access to BB data via so-called interfaces
- C++ wrapper class with `read()` and `write()` operations
- Interfaces are instantiated by the InterfaceManager
- There may be only one writer instance at any one time per Interface
- Protected with Read/Write locks
- Interface generator to transform XML descriptions into code

Configuration Subsystem

- C++ interface defines access independently of implementation
- Currently SQLite implementation exists
- Configurations may be tagged, used for instance for different locations and backups
- Handlers can be registered that are immediately notified of any configuration modification
- Network protocol and tool implemented to modify configuration
- Default and host configuration (overlay to default)

Network Communication

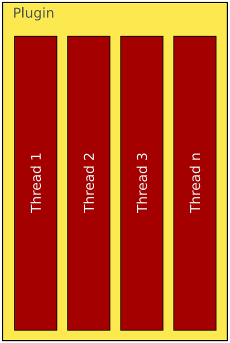
- Fawkes Network Protocol implemented
- TCP connection, announced and found via mDNS-SD
- Arbitrary communication can happen over the Fawkes connection
- Currently: PluginManager, ConfigurationManager
- BlackBoard communication inside Fawkes (tbd)
- Multicast inter-robot communication about world information (wip)

Main Application

- Implements the infrastructure using previously shown components
- Uses managers to handle configuration, plugins etc.
- Network communication handled by managers or plugins
- Fawkes main thread handles timing and basic synchronization
- Is the only application run on the robot
- Plugins are loaded dynamically

Plugins

- Module for a specific task
- Consists of one or more threads
- Threads are initialized
- It is guaranteed that either all threads are successfully initialized or none is started at all



Aspects and the Tulip Principle

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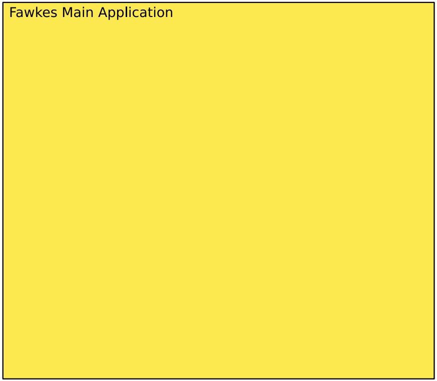
- *BlockedTimingAspect:* thread integrates into the main loop
- *BlackBoardAspect:* thread needs access to the BlackBoard
- *ConfigurableAspect:* thread uses a configuration
- *LoggingAspect:* thread writes output to a logger

Aspect Initialisation

- Aspects are initialised by the AspectInitializer
- If any error occurs during the initialisation of an aspect the thread is never started
- Aspects are a clean way to add functionality with minimum overhead
- No further initialisation inside the thread needed, just deriving the aspect base class is sufficient
- Knowledge on how to handle a thread can be derived from the aspects

Fawkes Diagram



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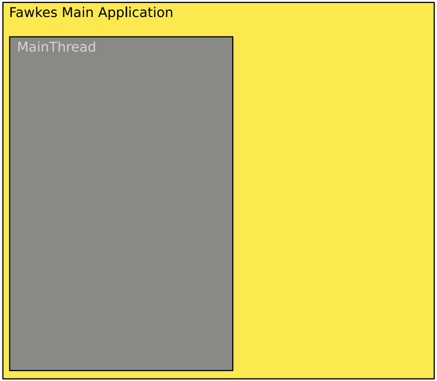

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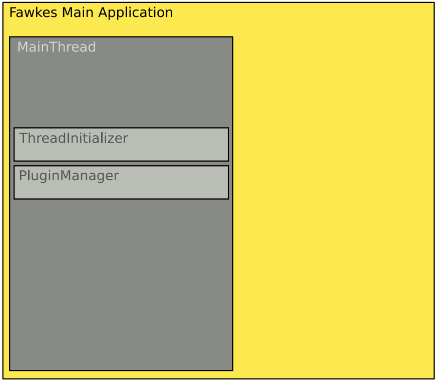

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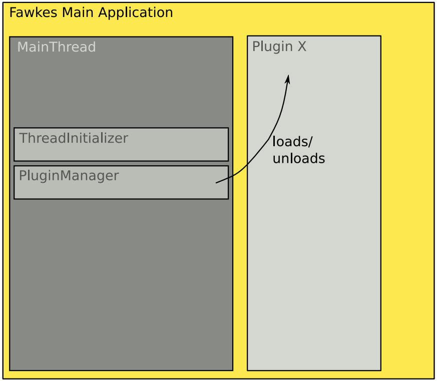

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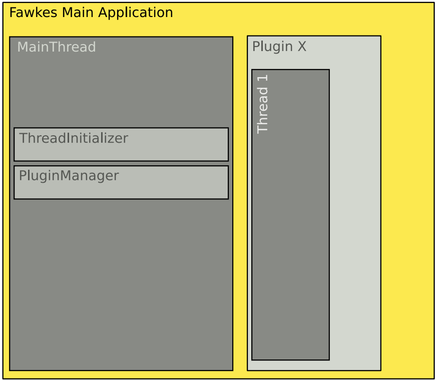

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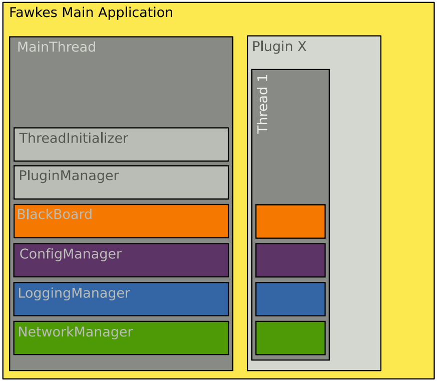

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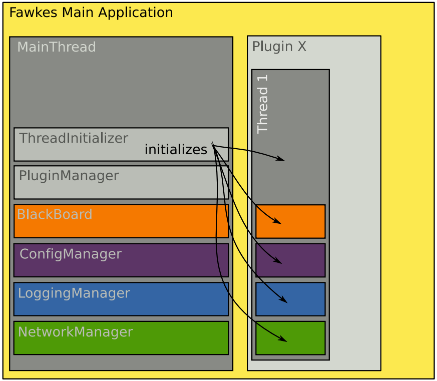

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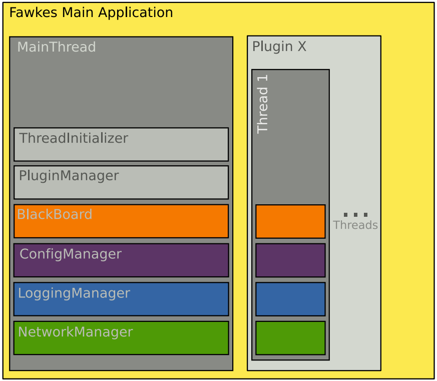

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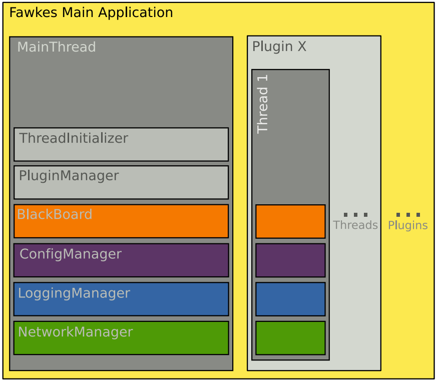

1 Retrospective

2 Design Goals

3 Components

4 Development
- Principles
- Improvements
- Implementing a Plugin
- Adding an Aspect
- Running Fawkes

5 Loose Ends

Fawkes Development Principles

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- Document all your code immediately
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- Exploit all available tools, use gdb and valgrind
- Use what’s there, do not re-invent the wheel

Improvements to Development Tools

- Subversion for version control
  - Finally refactoring is fun (move cmd)
  - Blame command to see originator
  - Offline operations for status, diffs etc.

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- Trac
  - Source code browser
  - Ticket management for bugs and features
  - Timeline and Roadmap
  - Access to documentation, API reference and wiki

Creating the Threads

- Derivative of Thread
- If needed use WAITFORWAKEUP mode (thread will wait after every loop for a wake-up call, needed for BlockedTimingAspect)
- Do all initialisation in the constructor
- Implement `loop()` to do what you need to do
- Add any aspect that you need by deriving its aspect class
- If threads need synchronisation among each other pass the needed constructs to the constructor (consider a synchronized shared data object)

Creating a Plugin

- Derivative of Plugin
- Implement plugin's threads
- Implement `threads()` to return a list of instantiated threads, take care of inter-thread synchronisation details here
- Implement `plugin_factory()` and `plugin_destroy()`

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First steps

Use `src/plugins/example` as a template. It contains a basic plugin that will run a few simple threads.

Creating an Interface

- Write XML template in `src/interfaces`
- `make`
- This will build `.h`/`.cpp` file and compile
- Use it
- Documentation yet to be written

Creating an Aspect

- Plain class, may not derive anything
- May use any library, avoid big fat external dependencies
- May not have pure virtual functions
- May have special constructor
- May have initialization routine, name specific to avoid name clashes (not `init()` but `MyAspect::initMyAspect()`)
- Make AspectInitializer know how to initialize the aspect and to detect any problems to meet guarantees
- Document extensively

Fawkes Tools

- `config`: Configuration editing over the network
- `plugin`: Load and unload plugins
- `interface_generator`: Transform BB interface XML templates into code
- use `-H` argument for a usage message (file a bug if missing!)

Running Fawkes

```
./fawkes
```

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Done

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- BlackBoard basics (data storage, messaging)
- Network communication (Fawkes Network Protocol)
- Basic utility library
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Enough to implement the first plugins and tune the call dynamics.

To Do

- BlackBoard logging and events
- BlackBoard introspection (+ visual tool)
- Geometry/math library (wip)
- Multicast world info transceiver (wip)
- Porting vision (wip)
- Implementing base applications (world model, agent etc.)
- New control center (probably not for RC2007)
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The foundation has been constructed, now it needs combined efforts to get it fly.

Questions and Discussion