Loosely Coupled Communication in Actor Systems

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Motivation

- Internet of Things (IoT)
  - Vulnerable
  - Low-powered & lossy connections
- Internet-wide systems
  - Software should scale on demand
  - No downtime due to failure of subsystems
  - Dynamic, world-wide deployment
    - Unknown when the code is written

Agenda

1. The Actor Model
2. `libcppa`
3. Loosely Coupled Communication
4. Use Cases
5. Challenges
6. Conferences & Key Players

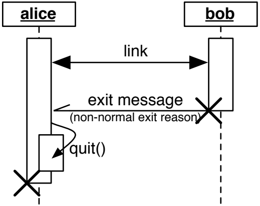
The Actor Model

Actors are concurrent entities, that ...

- Communicate via message passing
- Do not share state
- Can create ("spawn") new actors
- Can monitor other actors

Benefits

- High-level, explicit communication: no locks, no implicit sharing
- Applies to both concurrency *and* distribution
  - Divide workload by spawning actors
  - Interact via network-transparent messaging
  - Run transparently on heterogenous hardware
- Failure semantics
  - Links / Monitors
  - Hierarchical error management
  - Re-deployment at runtime



Implementations

- Erlang
  - Designed by Joe Armstrong at Ericsson in 1986
  - De-facto implementation of the actor model
  - Wide-spread use
  - Inspired other implementations
- Akka
  - Library for Scala based on the actor model
  - Initiated by Jonas Bonér in 2009
  - Developed by Typesafe Inc.
  - Included in the standard library
- `libcppa`

Agenda

1 The Actor Model

2 `libcppa`

3 Loosely Coupled Communication

4 Use Cases

5 Challenges

6 Conferences & Key Players

Features

- Developed by iNET working group at the HAW
- `libcppa` is an actor system based on C++11
- Efficient program execution
  - Low memory footprint
  - Fast, lock-free mailbox implementation
- Targets both low-end and high-performance computing
  - Embedded HW, e.g., running RIOT (http://www.riot-os.org)
  - Large multi-core systems
- Uses internal DSL for pattern matching of messages
- Transparent integration of OpenCL-based actors

Example

```
void math_server() {
  become (
    on(atom("plus"), arg_match) >> [](int a, int b) {
      return make_cow_tuple(atom("result"), a + b);
    }
  );
}
void math_client(actor_ptr ms) {
  sync_send(ms, atom("plus"), 40, 2).then(
    on(atom("result"), arg_match) >> [=](int result){
      cout << "40 + 2 = " << result << endl;
    }
  );
}
int main() {
  spawn(math_client, spawn(math_server));
  // ...
}
```

Linking Actors

```
void bob_fun(); // will fail
void alice_fun() {
  auto bob = spawn<linked>(bob_fun);
  send(bob, "hello bob");
  become ( /* will bob ever call back? */ );
}
void carl() {
  self->trap_exit(true);
  auto alice = spawn<linked>(alice_fun);
  become (
    on(atom("EXIT"), arg_match) >> [](uint32_t r) {
      if (r != exit_reason::normal)
        cout << "something went wrong..." << endl;
    }
  );
}
```

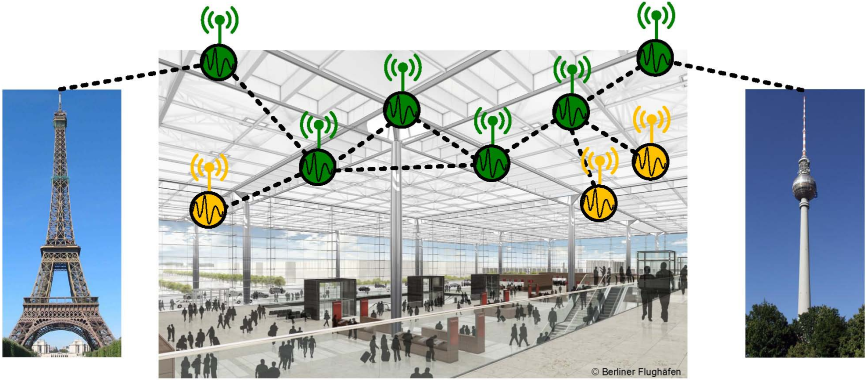
Agenda

Characteristics

- No global state
- Orchestration of independent systems
- Highly scalable
  - Performance depends on cores / nodes
  - Dynamic acquisition of resources based on demand
- Facade-like interfaces
  - Unknown implementation
  - Based on message content
- Suitable for long-distance traffic
  - Unreliable connections
  - Changing topology
  - Tolerant to interference
  - Asynchronous

Agenda

Safest



- Cooperation between:
  - France & Germany
  - Daviko, Forschungsforum Öffentliche Sicherheit, Fraunhofer FOKUS, FU Berlin, HAW Hamburg, INRIA, SAGEM
- Deployed at the airport Berlin Brandenburg

Safest

- Area surveillance system
- Resilient against malfunctions of components
- Respect privacy of citizens
- Distributed collection of anonymized data
- Stepwise evaluation towards central event processing
- Alerts the operator and/or the general public
- Nodes run RIOT & libcppa
    - High-Level modeling & development in the actor model
    - Development & tests on desktop systems
    - Seamless deployment to nodes

Publish/Subscribe

- Scalability
- Decoupled in space / time
- Easy way to deploy redundancy
- Examples:
  - Multicast
  - Information Centric Networking
  - Key-value storage

Agenda

Challenges
Security

- Verify identity of participants
- Ensure integrity of received messages
- Obtain robustness
- Find solutions for a decentralized system
- Changes have local impact

Challenges
Fault-tolerance

- Implement monitors/links for different scenarios
  - Multicast
  - Internet-wide systems
  - Low-powered & lossy connections
- Handle unreliable connections
- Deploy reliable services

Challenges

Communication

- Communicate with unknown systems
  - Rendezvous processes
- Minimize communication overhead
- Failures in pub/sub environments
- Error propagation in non-hierarchical actor systems

Agenda

Conferences

- C++Now
  - Focused on C++
  - May 2014 in Aspen, Colorado
- Splash → Agere!
  - Special Interest Group of ACM focused on Programming Languages
  - Actors, Agents, and Decentralized Control
- ICDCS
  - International Conference on Distributed Computing Systems
  - June / July 2014 in Spain
- PODC
  - ACM Symposium on Principles of Distributed Computing
  - July 2014 in Paris
- USENIX OSDI
  - USENIX Symposium on Operating Systems Design and Implementation
  - October 2014 in Broomfield, Colorado

Key Players

- Carl Hewitt
  - Initial paper on actors
  - Worked on actor model in 1973
- Gul Agha
  - Doctoral student of Hewitt
  - University of Illinois
  - On the Steering committee of the Agere
- Joe Armstrong
  - Developed Erlang in 1986

Key Players
Scala / Akka

- Martin Odersky
  - Professor at the École polytechnique fédérale de Lausanne (EPFL)
  - Developed Scala
- Philipp Haller
  - PhD in Computer Science from EPFL
  - Developed original actor implementation for Scala
- Jonas Bonér
  - Developed Akka
- Viktor Klang
  - Technical lead for the Akka project

Odersky, Bonér and Klang are part of Typesafe, a company focused on "Reactive Programming".

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Thank you for your attention.
Questions?

iNET: `http://inet.cpt.haw-hamburg.de`