BUILDING AN AUTOMATED TRADING SYSTEM USING ERLANG/OPT

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Berlin Erlang Factory Light
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1.1 Power quiz 1
1.2 Power quiz 2
1.3 Power quiz 3
1.4 Power quiz 4
2 Putting it all together …

Produce → Transmit → Consume
2.1 And trade…

Produce 传 Transmit 消
2.2 And where do we stand?

Produce → Transmit → Consume
2.3 Statkraft: headquartered in Norway

- Installed capacity: 17,600 MW
- 97% renewable energy
- Power production: 56 TWh
- 3,600 employees

### Countries and Projects

- **Sweden**
  - 1,315 MW
- **UK**
  - 273 MW
- **Germany**
  - 2,692 MW
- **Albania**
  - (project)
- **Panama**
  - (project)
- **Peru**
  - 163 MW (+ project)
- **Chile**
  - 94 MW
- **Brazil**
  - 86 MW (+ projects)
- **Turkey**
  - 20 MW (+ projects)
- **India**
  - 91 MW
- **Zambia**
  - 6 MW
- **Nepal**
  - 23 MW
- **Philippines**
  - 149 MW
- **Laos**
  - 100 MW

- **Installed capacity:** 17,600 MW
- **Power production:** 56 TWh

97% renewable energy

3,600 employees
2.4 Statkraft in Germany

Own generation 2 692 MW

≈ 7 500 MW

Virtual Power Plant:
Germany’s biggest asset
of remote controllable generation
3 German power market

- Physical Delivery
- Production ≡ Consumption
- EPEXSPOT - The Marketplace
  - Day Ahead Auction (12:00 D0 for D1)
  - Intraday Continuous Trading (24x7)
### 3.1 German power market: Contracts

<table>
<thead>
<tr>
<th>Time</th>
<th>07:00</th>
<th>07:15</th>
<th>07:30</th>
<th>07:45</th>
<th>08:00</th>
<th>08:15</th>
<th>08:30</th>
<th>08:45</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hr</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7Q1</td>
<td>7Q2</td>
<td>7Q3</td>
<td>7Q4</td>
<td>8Q1</td>
<td>8Q2</td>
<td>8Q3</td>
<td>8Q4</td>
<td></td>
</tr>
<tr>
<td><strong>Qt</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Hr**: H8 | H9
- **Qt**: 7Q1 | 7Q2 | 7Q3 | 7Q4 | 8Q1 | 8Q2 | 8Q3 | 8Q4
- **Block**: 07:00-08:00
3.2 Intraday optimization

Day Ahead: Plan

Intraday: Optimization
4 Sharpen tools

- amqp_client (https://github.com/jbrisbin/amqp_client.git)
- erlsom (https://github.com/willemdj/erlsom)
- gproc (https://github.com/uwiger/gproc.git)
- lager (https://github.com/basho/lager.git)
- rebar (https://github.com/basho/rebar)
- cowboy (https://github.com/extend/cowboy.git)
- jsx (https://github.com/talentdeficit/jsx)

Jon Brisbin
jbrisbin

Ulf Wiger
uwiger

Alisdair Sullivan
talentdeficit

99s

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5 Infrastructure overview

In case of failure we should switch to another Data Center
6. Do not build – Grow naturally!

Simplest application: Get data and show

Works 24x7

Survives outages
6.1 Version 0.1. Better view on bids and offers.

- http://XXX/XXX/epex_prices.html
6.2 Trim... Version 0.2

- Core
- Recorder
- Web Interface

Bot
Statistics
6.3 Core system. Version 0.2

- Root
  - Xml↔Rec
  - Login Srv
  - Broadcast
  - Contracts
  - Recorder
  - Public Trades
  - Own Trades
  - Private Orders

- Supervisor
- Worker
6.3.1 Core system V.0.2. Error processing

[Diagram showing the structure of the system with nodes labeled asXml↔Rec, Login Srv, Broadcast, Contracts, Recorder, Private Orders, Public Trades, Own Trades, and Supervisor and Worker roles indicated.]

Malformed Msg
6.3.2 Core system V.0.2. Error processing

Supervisor  
Worker

Xm Rec  
Login Srv  
Broadcast  
Contracts  
Recorder  
Public Trades  
Own Trades  
Private Orders  
Malformed Msg
6.3.3 Core system V.0.2. Error processing

- **XmlRec**
- **Login Srv**
- **Broadcast**
- **Contracts**
- **Recorder**
- **Public Trades**
- **Own Trades**
- **Private Orders**

**Errors**
- **Malformed Msg**
- **Kill**

- **Supervisor**
- **Worker**
6.3.4 Core system V.0.2. Pro and Cons

- Simple
- Efficient

Exchange does not like it
6.3.5 Core system V.0.2. Keep connection alive!

- **Supervisor**
- **Worker**

Diagram:
- **Root**
  - **Contracts**
    - **Public Trades**
    - **Own Trades**
  - **Recorder**
  - **Broadcast**
    - **Login Srv**
      - Malformed Msg
    - **Private Orders**
  - **XmℓRec**
    - Kill Worker

6.3.6 Just change a few lines... Core system V.0.3

- **Root**
  - **Xml**
    - Xml↔Rec
  - **Exchange**
    - **Contracts**
    - **Public Trades**
    - **Own Trades**
  - **Broadcast**
  - **Private Orders**

- **Supervisor**
- **Worker**

**Isolated Worker**
6.4 Episode 0.4. Attack of the Bots
6.4.1 Episode 0.4. Attack of the bots

Add a “primitive Bot”: “Buy Low – Sell High”
All trades are user confirmed.
6.4.2 Episode 0.4. Attack of the BOOSTED bots

Warning!!! Bot in Action!

Contract: **10:00-11:00** BUY **25 MW** at **60 €**

Confirm | Cancel

Buzzer: Speed and Fun!
7 Ready for launch? 5,4,3,2,1; ignition...

Mind the Knights...
7.1 Knight Capital: $440 Mio for the switch….

“There is NO KILL SWITCH;

the minute you hit the send button on an algo it’s running and you can’t stop it,”

Ken Polcari, managing director at ICAP Equities.

From “HFT traders under fire after algo glitch”
By Michael Mackenzie and Arash Massoudi in New York
7.2 Overlord will stop the bots!
7.3.0 Where is the switch? Step-by-step

Login Srv

Broadcast

Exchange
Bot
Overlord
Statistics
7.3.1 Where is the switch? Step-by-step
7.3.2 Where is the switch? Step-by-step

- Broadcast
- Login Srv
- Action?

Change

Exchange
Overlord
Bot
Statistics

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7.3.3 Where is the switch? Step-by-step
7.3.4 Where is the switch? Step-by-step

- Login Srv
- Action
- Action?
- Check

Exchange  
Bot  
Overlord  
Statistics  
Broadcast  
Change  
Change
7.3.5 Where is the switch? Step-by-step

- Broadcast
- Login Srv
- Action
- Action?
- Check
- Change
- Change
- Overlord
- Bot
- Exchange
- Statistics
7.3.6 Where is the switch? Is it over?

[Diagram showing interactions between various components such as Exchange, Bot, Overlord, Statistics, Login Srv, Action, Action?, Check, and Broadcast with arrows indicating flow and interaction.]
8 A closer look: To trade or not to trade?

<table>
<thead>
<tr>
<th>Public Orders 10:00-11:00</th>
<th>Private Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bid</strong></td>
<td><strong>Contract</strong></td>
</tr>
<tr>
<td><strong>Ask</strong></td>
<td><strong>Buy/Sell</strong></td>
</tr>
<tr>
<td>MW</td>
<td><strong>Volume</strong></td>
</tr>
<tr>
<td>15 MW</td>
<td><strong>Price</strong></td>
</tr>
<tr>
<td>20.0€</td>
<td>09:00-10:00</td>
</tr>
<tr>
<td>21.0€</td>
<td>Buy</td>
</tr>
<tr>
<td>50 MW</td>
<td>10</td>
</tr>
<tr>
<td>18.0€</td>
<td>09:00-10:00</td>
</tr>
<tr>
<td>23.0€</td>
<td>Sell</td>
</tr>
<tr>
<td>10 MW</td>
<td>20</td>
</tr>
<tr>
<td>10.0€</td>
<td>10:00-11:00</td>
</tr>
<tr>
<td>30.0€</td>
<td>Buy</td>
</tr>
<tr>
<td>50 MW</td>
<td>15</td>
</tr>
<tr>
<td>10.0€</td>
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</tr>
<tr>
<td>30.0€</td>
<td>Sell</td>
</tr>
<tr>
<td>50 MW</td>
<td>10</td>
</tr>
</tbody>
</table>

**Check**

10:00-11:00 Sell 10 @ 20.0€
### 8 A closer look: To trade or not to trade?

#### Public Orders 10:00-11:00

<table>
<thead>
<tr>
<th>Bid</th>
<th>Ask</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW</td>
<td>€</td>
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<td>23.0€</td>
</tr>
<tr>
<td>10</td>
<td>10.0€</td>
<td>30.0€</td>
</tr>
</tbody>
</table>

#### Private Orders

<table>
<thead>
<tr>
<th>Contract</th>
<th>Buy/Sell</th>
<th>Volume</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00-10:00</td>
<td>Buy</td>
<td>10</td>
<td>30.0€</td>
</tr>
<tr>
<td>09:00-10:00</td>
<td>Sell</td>
<td>20</td>
<td>35.0€</td>
</tr>
<tr>
<td>10:00-11:00</td>
<td>Buy</td>
<td>15</td>
<td>20.0€</td>
</tr>
<tr>
<td>11:00-12:00</td>
<td>Sell</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

**Check** 10:00-11:00 Sell 10 @ 20.0€

**NO**
8 A closer look: Not to ...

<table>
<thead>
<tr>
<th>Public Orders 10:00-11:00</th>
<th>Private Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bid</strong></td>
<td><strong>Contract</strong></td>
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<tr>
<td><strong>Ask</strong></td>
<td><strong>Buy/Sell</strong></td>
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</tr>
<tr>
<td>11:00-12:00</td>
<td>Sell</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Check 10:00-11:00 Sell 10 @ 20.0€
8.1 Do not trade your own orders
8.2 Do not trade your own orders
8.3 Do not trade your own orders
8.4 Do not trade your own orders. Done?
9.0 Mind the Time: An Ideal World

<table>
<thead>
<tr>
<th>T+0</th>
<th>T+1</th>
<th>T+2</th>
<th>T+3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Orders</td>
<td>Broadcast</td>
<td>Change</td>
<td>Change</td>
</tr>
<tr>
<td>Public Trades</td>
<td>Change</td>
<td>Public Trades</td>
<td>Change</td>
</tr>
<tr>
<td>Own Trades</td>
<td>Change</td>
<td>Own Trades</td>
<td>Change</td>
</tr>
</tbody>
</table>

Time
9.1 Mind the Time. The Real World

Time

T+0...M

- Private Orders
- Public Trades
- Own Trades

Broadcast

T+1...N

- Change
- Private Orders
- Change
- Public Trades
- Change
- Own Trades
- Change

Change

Change

Change

Change

Change

Change

Change

Change

Stats
9.2.0 Dealing with the Real World

- Login Srv
- Private Orders
- Broadcast
- Action?
- Change

- Overlord
- Bot
- Exchange
- Statistics
9.2.1 Dealing with the Real World

- Exchange
- Bot
- Overlord
- Statistics

- Login Srv
- Private Orders
- Broadcast

Action?
Check
Change
Check
Change
9.2.2 Dealing with the Real World

- Login Srv
- Action
- Check
- Action?
- Private Orders
- Check
- Change
- Broadcast

Exchange
Bot
Overlord
Statistics
9.2.3 Dealing with the Real World. Magic is here
9.2.4 Dealing with the Real World. Magic is here
9.2.5 Dealing with the Real World. Waiting for a message

- Login Srv
- Action
- Check
- Action
- Action
- Check
- Action?

- Private Orders
- Broadcast
- Change
- Change

- Action
- Private Orders

- Exchange
- Bot
- Overlord
- Statistics

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9.2.6 Dealing with the Real World. Waiting for a message
9.2.7 Dealing with the Real World. Cancel the change
9.2.8 Dealing with the Real World. DONE!
10. Lessons learned

- Erlang is cool 😊
- Log everything
- Automated mode ≠ very fast manual mode
- Be aware of dependencies: next change could crash your system
- Test it
- Test it
- Test mode ≠ Live mode
- Keep it simple, do not plan for the future
- Keep it simple and plan for the future
- Measure performance
11. Open issues: Performance measurement

- folsom
- estatsd
- exometer

VS

- `timer:tc()` + lagger + grep
11. Open issues: Performance deviation
Questions?