Speak Binary to Me

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"Smart" stuff

- Remote terminal units (RTU)
- Programmable logic controllers (PLC)
- Solar inverters
- Heatpumps
- Electricity meters
- Thermostats, window blinds, door contacts
- Various sensors and actuators
The BEAM advantage

- Fault tolerance
- State machines
- Concurrency
The BEAM advantage

- Fault tolerance
- State machines
- Concurrency
- Bit syntax
BINARIES
Computers
Binaries and notations

$0b01001011$ $<=>$ 75 $<=>$ 0x4B

Binary $<=>$ Decimal $<=>$ Hex

Voltage

```
0 1 0 1 0 0 1 0 1 1
```

Time
Binaries and notations

\[ 0b01001011 \iff 75 \iff 0x4B \]
Binary \iff Decimal \iff Hex
Binaries and notations

\[0b01001011 \iff 75 \iff 0x4B\]
Binary \iff Decimal \iff Hex
IPv4 address

192.168.1.10

0b11000000 0b10101000 0b00000001 0b00001010
MAC address

AD:04:5E:00:53:AF

0b10101101 0b00000100 0b01011110
0b00000000 0b01010011 0b10101111
BIT SYNTAX
Encoding a binary

my_binary = ???????
Encoding a binary

my_binary = <<10, 20, 30>>
Decoding a binary

```ruby
# my_binary = <<10, 20, 30>>
?????????????? = my_binary
# a = 10, b = 20, c = 30
```
Decoding a binary

# my_binary = <<10, 20, 30>>
<<a, b, c>> = my_binary
# a = 10, b = 20, c = 30
Are we done?
Encoding with modifiers

```python
my_binary = <<
  10::integer-unsigned-size(8)-unit(1)-big,
  20::integer-unsigned-8-unit(1)-big,
  30
>>
```

Modifiers: **type**, **sign**, **size**, **unit** and **endianness**.
Decoding with modifiers

<<
    a::integer-unsigned-size(8)-unit(1)-big,
    b::integer-unsigned-8-unit(1)-big,
    c
>> = my_binary
Protocol programming in Erlang using binaries

Claes Wikström Tony Rogvall*
Computer Science Laboratory
Ericsson Telecom AB

29 Sep 1998
Back to endianness

41665 == 0xA2C1
### Back to endianness

\[
41665 \equiv 0xA2C1
\]

<table>
<thead>
<tr>
<th>MSB</th>
<th>LSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>0xA2C1</td>
<td>0xC1A2</td>
</tr>
</tbody>
</table>

Big-endian  
Little-endian
ON HOLY WARS AND A PLEA FOR PEACE

INTRODUCTION

This is an attempt to stop a war. I hope it is not too late and that somehow, magically perhaps, peace will prevail again.
Gulliver's Travels
EXAMPLES
TBox

Has name, measures temperature
# TBox message format

<table>
<thead>
<tr>
<th>Header (1 byte)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Value (reply-only, length depends on header)</td>
<td></td>
</tr>
</tbody>
</table>
TBox header

| MAGIC (4 bits) | DIR (1 bit) | ATT (3 bits) |

- **MAGIC**: Constant (0xA / 0b1010)
- **DIR**: Request (0x0 / 0b0) or Reply (0x1 / 0b1)
- **ATT**: NAME (0x0 / 0b000), TEMP (0x1 / 0b001)
TBox request/reply

| 1010 | 0 | 001 | ---> TBox (request) |
|------|---|-----|
| 1010 | 1 | 001 | <--- TBox (reply) |
| VAL byte 1 ... |
| VAL byte n |
| NAME (12 ASCII bytes) |
TBox name example
"FOSDEM"

<table>
<thead>
<tr>
<th>01000110</th>
<th>01001111</th>
<th>01010011</th>
<th>01000100</th>
</tr>
</thead>
<tbody>
<tr>
<td>01000101</td>
<td>01001101</td>
<td>00000000</td>
<td>00000000</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>01000101</td>
<td>01001101</td>
<td>00000000</td>
<td>00000000</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>00000000</td>
<td>00000000</td>
<td>00000000</td>
<td>00000000</td>
</tr>
</tbody>
</table>
TBox VAL temperature

<table>
<thead>
<tr>
<th>TIME (32 bit integer)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TEMP (16 bit float)</td>
<td>Q (byte)</td>
</tr>
</tbody>
</table>

Numbers are little-endian!
TBox temperature example

<table>
<thead>
<tr>
<th>11010101</th>
<th>01111101</th>
<th>11011001</th>
<th>01100011</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000100</td>
<td>01010000</td>
<td>00000011</td>
<td></td>
</tr>
</tbody>
</table>

| 00000100 | 01010000 | 00000011 |
Get TBox name

request = <<0xA::4, 0::1, 0::3>>
Get TBox name

request = <<0xA::4, 0::1, 0::3>>

<<
  0xA::4, 1::1, 0::3,
  name::bytes-12
>> = reply
Get TBox temperature

request = <<0xA::4, 0::1, 1::3>>
Get TBox temperature

```
request = <<0xA::4, 0::1, 1::3>>

<<
  0xA::4, 1::1, 1::3,
  timestamp::32-little,
  temperature::float-16-little,
  _::6, clock_error::1, temperature_error::1
>> = reply
```
So much to cover

- Streaming
- Generators
- Performance tuning
- Other tools (Wireshark, tcpdump, btmon...)
Check out Protohackers

- protohackers.com
- Andrea Leopardi's live stream on YouTube
Thank you

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