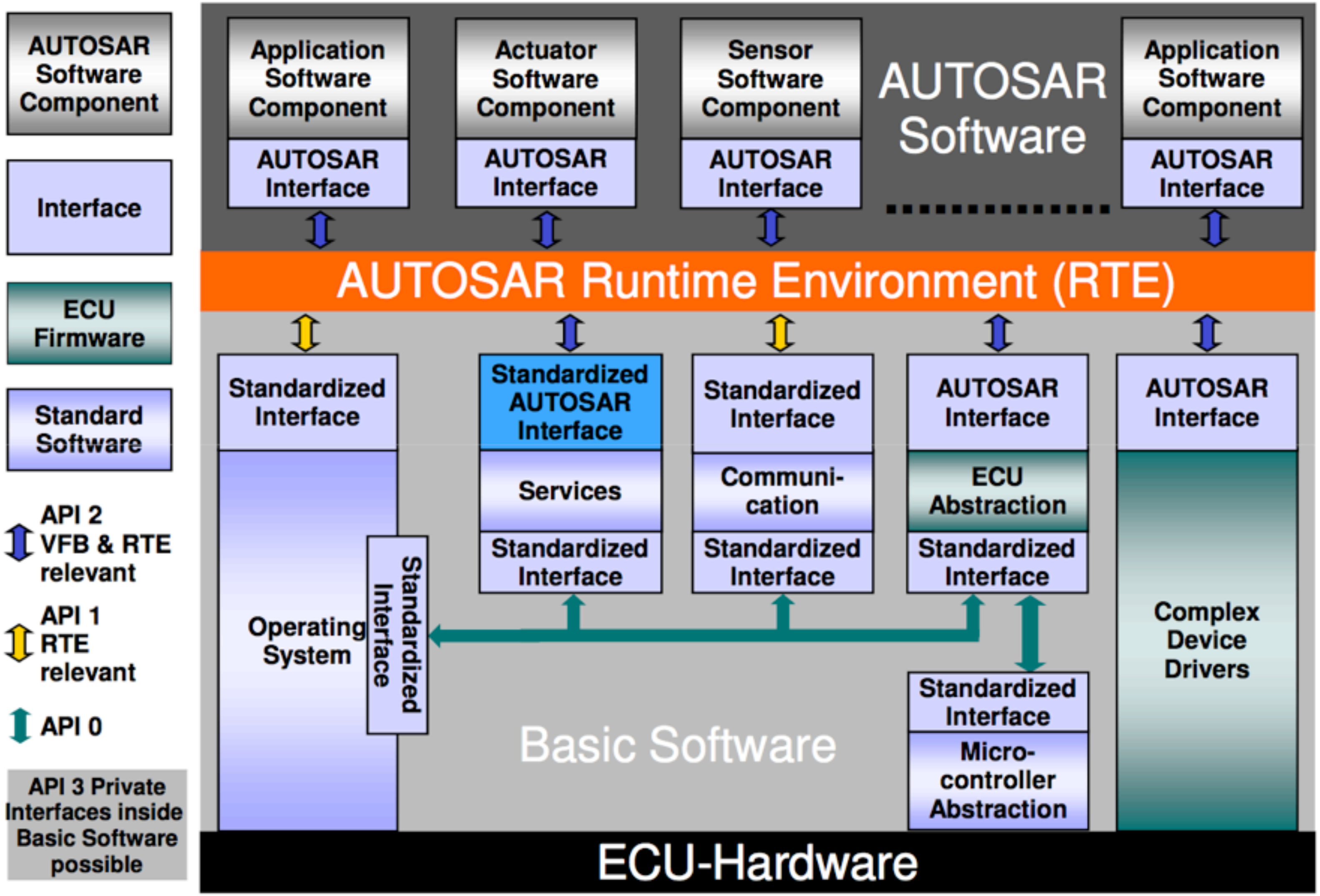
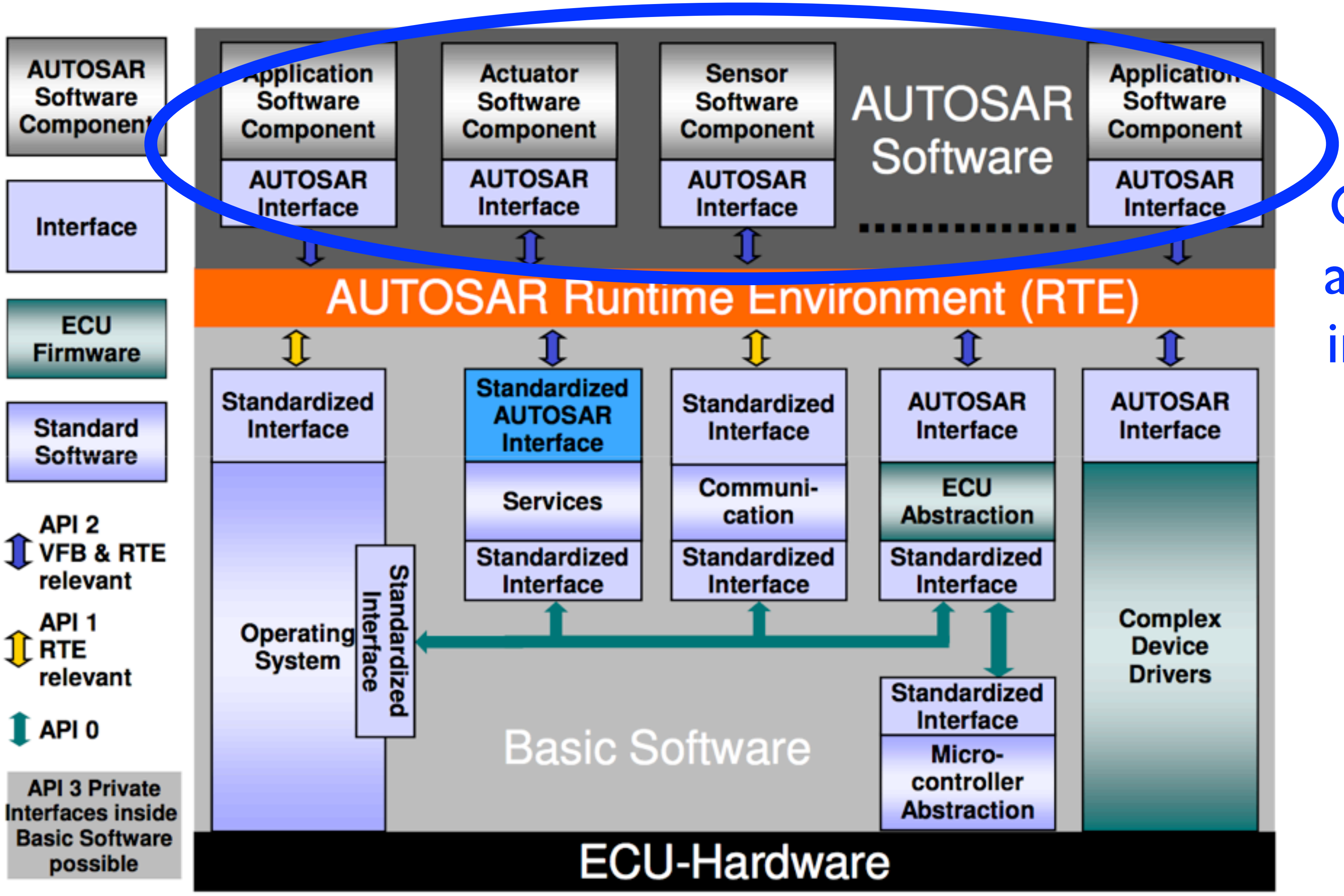
Resource Aware Functional Programming in the Automotive Domain

Applying DSEL technology to concurrent, distributed and real-time software under the AUTOSAR standard

AUTOSAR architecture

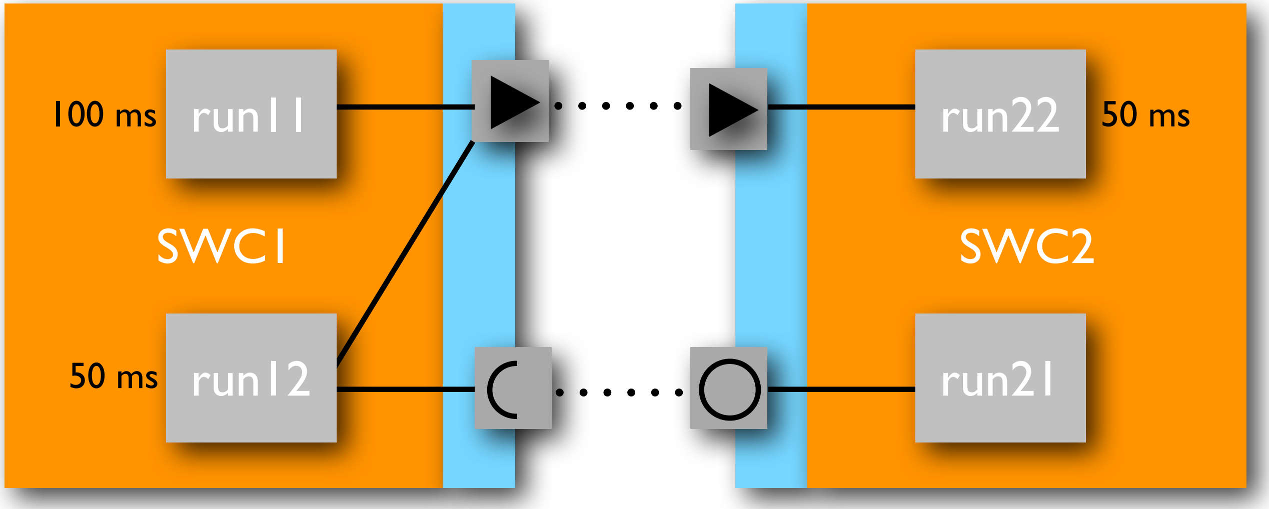


AUTOSAR architecture



Captured as a DSEL in Haskell

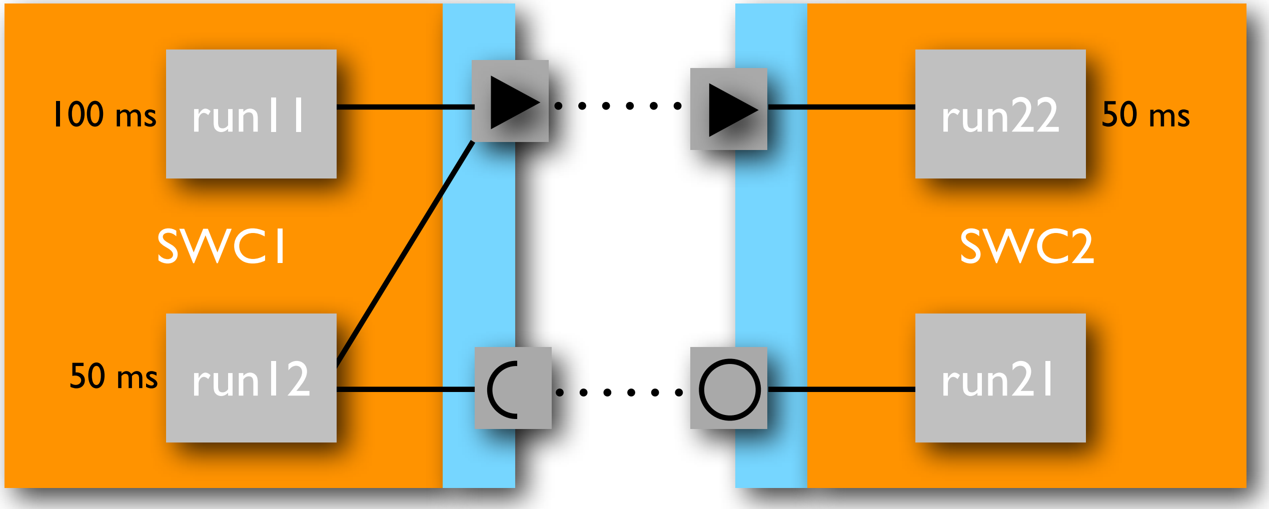
Simple example



Simple example

```
FUNC(void, RTE APPL CODE) run11(void) {
    Int16 val;
    ...
    Rte_Write_pport1_intValue1(val);
    ...
}
```

```
FUNC(void, RTE APPL CODE) run22(void) {
    Int16 val;
    ...
    Rte_Read_rport2_intValue(&val);
    ...
}
```



```
FUNC(void, RTE APPL CODE) run12(void) {
    String8 val1;
    Int16 val2;
    ...
    Rte_Call_rport1_parse(val1, &val2);
    ...
    Rte_Write_pport1_intValue1(val2);
    ...
}
```

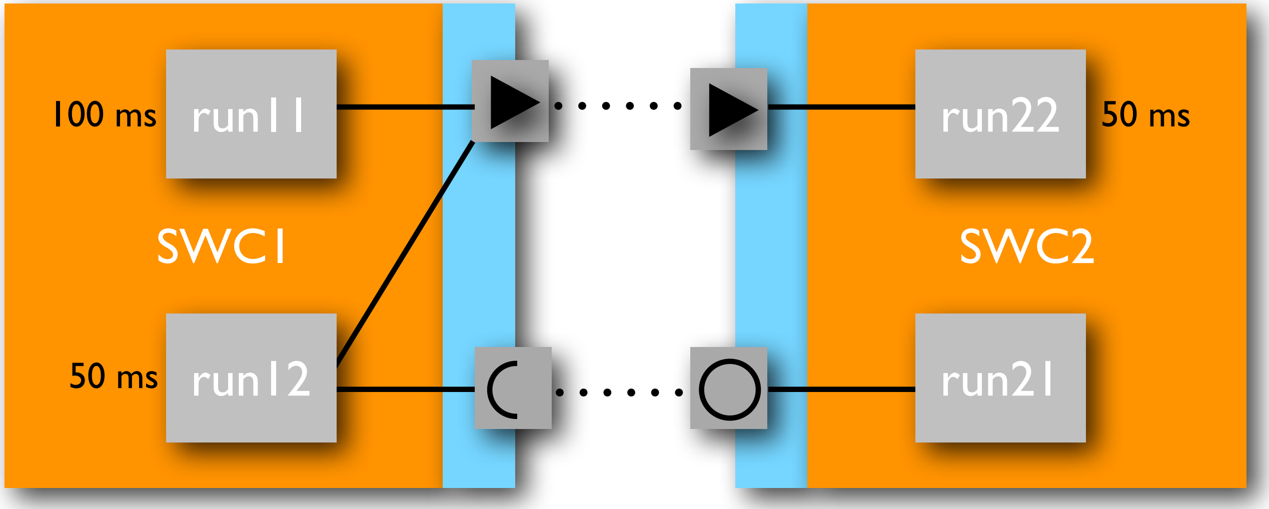
```
FUNC(void, RTE APPL CODE) run21(String8 arg, Int16 *res ) {
    ... arg ...
    ...
    *res = ...
}
```

Simple example

```
FUNC(void, RTE APPL CODE) run11(void) {
    Int16 val;
    ...
    Rte_Write_pport1_intValue1(val);
    ...
}
```

```
FUNC(void, RTE APPL CODE) run22(void) {
    Int16 val;
    ...
    Rte_Read_rport2_intValue(&val);
    ...
}
```

```
TASK(Task1) {
   Rte RECount_Task1_divby2_0––;
   if ( Rte_RECount_Task1_divby2_0 == 0 ) {
      run11();
   }
   run12();
   if ( Rte_RECount_Task1_divby2_0 == 0 )
      Rte_RECount_Task1_divby2_0 = 2;
   TerminateTask();
}
```



```
FUNC(void, RTE APPL CODE) run12(void) {
    String8 val1;
    Int16 val2;
    ...
    Rte_Call_rport1_parse(val1, &val2);
    ...
    Rte_Write_pport1_intValue1(val2);
    ...
}
```

```
FUNC(void, RTE APPL CODE) run21(String8 arg, Int16 *res ) {
    ... arg ...
    ...
    *res = ...
}
```

Simple example

```
<AR-PACKAGE>
    <SHORT-NAME>swc root</SHORT-NAME>
    <ELEMENTS>
        <ATOMIC-SOFTWARE-COMPONENT-TYPE>
            <SHORT-NAME>swc1</SHORT-NAME>
            <PORTS>
                <P-PORT-PROTOTYPE>
                    <SHORT-NAME>pport1</SHORT-NAME>
                    <PROVIDED-INTERFACE-TREF DEST="SENDER-RECEIVER-INTERFACE">
                        /interfaces/SR Int16
                    </PROVIDED-INTERFACE-TREF>
                </P-PORT-PROTOTYPE>
                <R-PORT-PROTOTYPE>
                    <SHORT-NAME>rport1</SHORT-NAME>
                    <REQUIRED-INTERFACE-TREF DEST="CLIENT-SERVER-INTERFACE">
                        /interfaces/CS string to int
                    </REQUIRED-INTERFACE-TREF>
                </R-PORT-PROTOTYPE>
            </PORTS>
        </ATOMIC-SOFTWARE-COMPONENT-TYPE>
        <ATOMIC-SOFTWARE-COMPONENT-TYPE>
            <SHORT-NAME>swc2</SHORT-NAME>
            <PORTS>
                <P-PORT-PROTOTYPE>
                    <SHORT-NAME>pport1</SHORT-NAME>
                    <PROVIDED-INTERFACE-TREF DEST="CLIENT-SERVER-INTERFACE">
                        /interfaces/CS string to int
                    </PROVIDED-INTERFACE-TREF>
                </P-PORT-PROTOTYPE>
                <R-PORT-PROTOTYPE>
                    <SHORT-NAME>rport1</SHORT-NAME>
                    <REQUIRED-INTERFACE-TREF DEST="SENDER-RECEIVER-INTERFACE">
                        /interfaces/SR Int16
                    </REQUIRED-INTERFACE-TREF>
                </R-PORT-PROTOTYPE>
            </PORTS>
        </ATOMIC-SOFTWARE-COMPONENT-TYPE>
```

Simple example

```xml
<AR-PACKAGE>
   <SHORT-NAME>swc root</SHORT-NAME>
   <ELEMENTS>
      <ATOMIC-SOFTWARE-COMPONENT-TYPE>
         <SHORT-NAME>swc1</SHORT-NAME>
         <PORTS>
            <P-PORT-PROTOTYPE>
               <SHORT-NAME>pport1</SHORT-NAME>
               <PROVIDED-INTERFACE-TREF DEST="SENDER-RECEIVER-INTERFACE">
                  /interfaces/SR Int16
               </PROVIDED-INTERFACE-TREF>
            </P-PORT-PROTOTYPE>
            <R-PORT-PROTOTYPE>
               <SHORT-NAME>rport1</SHORT-NAME>
               <REQUIRED-INTERFACE-TREF DEST="CLIENT-SERVER-INTERFACE">
                  /interfaces/CS string to int
               </REQUIRED-INTERFACE-TREF>
            </R-PORT-PROTOTYPE>
         </PORTS>
      </ATOMIC-SOFTWARE-COMPONENT-TYPE>
      <ATOMIC-SOFTWARE-COMPONENT-TYPE>
         <SHORT-NAME>swc2</SHORT-NAME>
         <PORTS>
            <P-PORT-PROTOTYPE>
               <SHORT-NAME>pport1</SHORT-NAME>
               <PROVIDED-INTERFACE-TREF DEST="CLIENT-SERVER-INTERFACE">
                  /interfaces/CS string to int
               </PROVIDED-INTERFACE-TREF>
            </P-PORT-PROTOTYPE>
            <R-PORT-PROTOTYPE>
               <SHORT-NAME>rport1</SHORT-NAME>
               <REQUIRED-INTERFACE-TREF DEST="SENDER-RECEIVER-INTERFACE">
                  /interfaces/SR Int16
               </REQUIRED-INTERFACE-TREF>
            </R-PORT-PROTOTYPE>
         </PORTS>
      </ATOMIC-SOFTWARE-COMPONENT-TYPE>
```

```xml
<INTERNAL-BEHAVIOR>
   <SHORT-NAME>intBehSwc1</SHORT-NAME>
   <COMPONENT-REF DEST="ATOMIC-SOFTWARE-COMPONENT-TYPE">/swc root/swc1</COMPONENT-REF>
   <EVENTS>
      <TIMING-EVENT>
         <SHORT-NAME>Time100ms</SHORT-NAME>
         <START-ON-EVENT-REF DEST="RUNNABLE-ENTITY">
            /swc root/intBehSwc1/run11
         </START-ON-EVENT-REF>
         <PERIOD>0.1</PERIOD>
      </TIMING-EVENT>
      <TIMING-EVENT>
         <SHORT-NAME>Time50ms</SHORT-NAME>
         <START-ON-EVENT-REF DEST="RUNNABLE-ENTITY">
            /swc root/intBehSwc1/run12
         </START-ON-EVENT-REF>
         <PERIOD>0.05</PERIOD>
      </TIMING-EVENT>
   </EVENTS>
   <RUNNABLES>
      <RUNNABLE-ENTITY>
         <SHORT-NAME>run11</SHORT-NAME>
         <CAN-BE-INVOKED-CONCURRENTLY>false</CAN-BE-INVOKED-CONCURRENTLY>
         <DATA-SEND-POINTS>
            <DATA-SEND-POINT>
               <SHORT-NAME>dwa1</SHORT-NAME>
               <DATA-ELEMENT-IREF>
                  <P-PORT-PROTOTYPE-REF DEST="P-PORT-PROTOTYPE">
                     /swc root/swc1/pport1
                  </P-PORT-PROTOTYPE-REF>
                  <DATA-ELEMENT-PROTOTYPE-REF DEST="DATA-ELEMENT-PROTOTYPE">
                     /interfaces/SR Int16/intValue1
                  </DATA-ELEMENT-PROTOTYPE-REF>
               </DATA-ELEMENT-IREF>
            </DATA-SEND-POINT>
            <DATA-SEND-POINT>
               <SHORT-NAME>dwa2</SHORT-NAME>
               <DATA-ELEMENT-IREF>
                  <P-PORT-PROTOTYPE-REF DEST="P-PORT-PROTOTYPE">
                     /swc root/swc1/pport1
                  </P-PORT-PROTOTYPE-REF>
                  <DATA-ELEMENT-PROTOTYPE-REF DEST="DATA-ELEMENT-PROTOTYPE">
                     /interfaces/SR Int16/intValue2
                  </DATA-ELEMENT-PROTOTYPE-REF>
               </DATA-ELEMENT-IREF>
            </DATA-SEND-POINT>
         </DATA-SEND-POINTS>
         <SYMBOL>run11</SYMBOL>
      </RUNNABLE-ENTITY>
      <RUNNABLE-ENTITY>
         <SHORT-NAME>run12</SHORT-NAME>
         <CAN-BE-INVOKED-CONCURRENTLY>false</CAN-BE-INVOKED-CONCURRENTLY>
         <DATA-SEND-POINTS>
            <DATA-SEND-POINT>
               <SHORT-NAME>dwa2</SHORT-NAME>
               <DATA-ELEMENT-IREF>
                  <P-PORT-PROTOTYPE-REF DEST="P-PORT-PROTOTYPE">
                     /swc root/swc1/pport1
                  </P-PORT-PROTOTYPE-REF>
                  <DATA-ELEMENT-PROTOTYPE-REF DEST="DATA-ELEMENT-PROTOTYPE">
                     /interfaces/SR Int16/intValue1
                  </DATA-ELEMENT-PROTOTYPE-REF>
               </DATA-ELEMENT-IREF>
            </DATA-SEND-POINT>
         </DATA-SEND-POINTS>
         <SERVER-CALL-POINTS>
            <SYNCHRONOUS-SERVER-CALL-POINT>
               <SHORT-NAME>sscp</SHORT-NAME>
               <OPERATION-IREFS>
                  <OPERATION-IREF>
                     <R-PORT-PROTOTYPE-REF DEST="R-PORT-PROTOTYPE">
                        /swc root/swc1/rport1
                     </R-PORT-PROTOTYPE-REF>
                     <OPERATION-PROTOTYPE-REF DEST="OPERATION-PROTOTYPE">
                        /interfaces/CS string to int/parse
                     </OPERATION-PROTOTYPE-REF>
                  </OPERATION-IREF>
               </OPERATION-IREFS>
            </SYNCHRONOUS-SERVER-CALL-POINT>
         </SERVER-CALL-POINTS>
         <SYMBOL>run12</SYMBOL>
      </RUNNABLE-ENTITY>
   </RUNNABLES>
   <SUPPORTS-MULTIPLE-INSTANTIATION>false</SUPPORTS-MULTIPLE-INSTANTIATION>
</INTERNAL-BEHAVIOR>
```

Simple example

```
<AR-PACKAGE>
  <SHORT-NAME>swc root</SHORT-NAME>
  <ELEMENTS>
    <ATOMIC-SOFTWARE-COMPONENT-TYPE>
      <SHORT-NAME>swc1</SHORT-NAME>
      <PORTS>
        <P-PORT-PROTOTYPE>
          <SHORT-NAME>pport1</SHORT-NAME>
          <PROVIDED-INTERFACE-TREF DEST="SENDER-RECEIVER-INTERFACE">
            /interfaces/SR Int16
          </PROVIDED-INTERFACE-TREF>
        </P-PORT-PROTOTYPE>
        <R-PORT-PROTOTYPE>
          <SHORT-NAME>rport1</SHORT-NAME>
          <REQUIRED-INTERFACE-TREF DEST="CLIENT-SERVER-INTERFACE">
            /interfaces/CS string to int
          </REQUIRED-INTERFACE-TREF>
        </R-PORT-PROTOTYPE>
      </PORTS>
    </ATOMIC-SOFTWARE-COMPONENT-TYPE>
    <ATOMIC-SOFTWARE-COMPONENT-TYPE>
      <SHORT-NAME>swc2</SHORT-NAME>
      <PORTS>
        <P-PORT-PROTOTYPE>
          <SHORT-NAME>pport1</SHORT-NAME>
          <PROVIDED-INTERFACE-TREF DEST="CLIENT-SERVER-INTERFACE">
            /interfaces/CS string to int
          </PROVIDED-INTERFACE-TREF>
        </P-PORT-PROTOTYPE>
        <R-PORT-PROTOTYPE>
          <SHORT-NAME>rport1</SHORT-NAME>
          <REQUIRED-INTERFACE-TREF DEST="SENDER-RECEIVER-INTERFACE">
            /interfaces/SR Int16
          </REQUIRED-INTERFACE-TREF>
        </R-PORT-PROTOTYPE>
      </PORTS>
    </ATOMIC-SOFTWARE-COMPONENT-TYPE>
```

```
<INTERNAL-BEHAVIOR>
  <SHORT-NAME>intBehSwc1</SHORT-NAME>
  <COMPONENT-REF DEST="ATOMIC-SOFTWARE-COMPONENT-TYPE">/swc root/swc1</COMPONENT-REF>
  <EVENTS>
    <TIMING-EVENT>
      <SHORT-NAME>Time100ms</SHORT-NAME>
      <START-ON-EVENT-REF DEST="RUNNABLE-ENTITY">
        /swc root/intBehSwc1/run11
      </START-ON-EVENT-REF>
      <PERIOD>0.1</PERIOD>
    </TIMING-EVENT>
    <TIMING-EVENT>
      <SHORT-NAME>Time50ms</SHORT-NAME>
      <START-ON-EVENT-REF DEST="RUNNABLE-ENTITY">
        /swc root/intBehSwc1/run12
      </START-ON-EVENT-REF>
      <PERIOD>0.05</PERIOD>
    </TIMING-EVENT>
  </EVENTS>
  <RUNNABLES>
    <RUNNABLE-ENTITY>
      <SHORT-NAME>run11</SHORT-NAME>
      <CAN-BE-INVOKED-CONCURRENTLY>false</CAN-BE-INVOKED-CONCURRENTLY>
      <DATA-SEND-POINTS>
        <DATA-SEND-POINT>
          <SHORT-NAME>dwa1</SHORT-NAME>
          <DATA-ELEMENT-IREF>
            <P-PORT-PROTOTYPE-REF DEST="P-PORT-PROTOTYPE">
              /swc root/swc1/pport1
            </P-PORT-PROTOTYPE-REF>
            <DATA-ELEMENT-PROTOTYPE-REF DEST="DATA-ELEMENT-PROTOTYPE">
              /interfaces/SR Int16/intValue1
            </DATA-ELEMENT-PROTOTYPE-REF>
          </DATA-ELEMENT-IREF>
        </DATA-SEND-POINT>
        <DATA-SEND-POINT>
          <SHORT-NAME>dwa2</SHORT-NAME>
          <DATA-ELEMENT-IREF>
            <P-PORT-PROTOTYPE-REF DEST="P-PORT-PROTOTYPE">
              /swc root/swc1/pport1
            </P-PORT-PROTOTYPE-REF>
            <DATA-ELEMENT-PROTOTYPE-REF DEST="DATA-ELEMENT-PROTOTYPE">
              /interfaces/SR Int16/intValue2
            </DATA-ELEMENT-PROTOTYPE-REF>
          </DATA-ELEMENT-IREF>
        </DATA-SEND-POINT>
      </DATA-SEND-POINTS>
      <SYMBOL>run11</SYMBOL>
    </RUNNABLE-ENTITY>
    <RUNNABLE-ENTITY>
      <SHORT-NAME>run12</SHORT-NAME>
      <CAN-BE-INVOKED-CONCURRENTLY>false</CAN-BE-INVOKED-CONCURRENTLY>
      <DATA-SEND-POINTS>
        <DATA-SEND-POINT>
          <SHORT-NAME>dwa2</SHORT-NAME>
          <DATA-ELEMENT-IREF>
            <P-PORT-PROTOTYPE-REF DEST="P-PORT-PROTOTYPE">
              /swc root/swc1/pport1
            </P-PORT-PROTOTYPE-REF>
            <DATA-ELEMENT-PROTOTYPE-REF DEST="DATA-ELEMENT-PROTOTYPE">
              /interfaces/SR Int16/intValue1
            </DATA-ELEMENT-PROTOTYPE-REF>
          </DATA-ELEMENT-IREF>
        </DATA-SEND-POINT>
      </DATA-SEND-POINTS>
      <SERVER-CALL-POINTS>
        <SYNCHRONOUS-SERVER-CALL-POINT>
          <SHORT-NAME>sscp</SHORT-NAME>
          <OPERATION-IREFS>
            <OPERATION-IREF>
              <R-PORT-PROTOTYPE-REF DEST="R-PORT-PROTOTYPE">
                /swc root/swc1/rport1
              </R-PORT-PROTOTYPE-REF>
              <OPERATION-PROTOTYPE-REF DEST="OPERATION-PROTOTYPE">
                /interfaces/CS string to int/parse
              </OPERATION-PROTOTYPE-REF>
            </OPERATION-IREF>
          </OPERATION-IREFS>
        </SYNCHRONOUS-SERVER-CALL-POINT>
      </SERVER-CALL-POINTS>
      <SYMBOL>run12</SYMBOL>
    </RUNNABLE-ENTITY>
  </RUNNABLES>
  <SUPPORTS-MULTIPLE-INSTANTIATION>false</SUPPORTS-MULTIPLE-INSTANTIATION>
</INTERNAL-BEHAVIOR>
```

```
    <INTERNAL-BEHAVIOR>
      <SHORT-NAME>intBehSwc2</SHORT-NAME>
      <COMPONENT-REF DEST="ATOMIC-SOFTWARE-COMPONENT-TYPE">/swc root/swc2</COMPONENT-REF>
      <EVENTS>
        <TIMING-EVENT>
          <SHORT-NAME>Time50ms</SHORT-NAME>
          <START-ON-EVENT-REF DEST="RUNNABLE-ENTITY">
            /swc root/intBehSwc2/run22
          </START-ON-EVENT-REF>
          <PERIOD>0.05</PERIOD>
        </TIMING-EVENT>
        <OPERATION-INVOKED-EVENT>
          <SHORT-NAME>operationInvoke</SHORT-NAME>
          <START-ON-EVENT-REF DEST="RUNNABLE-ENTITY">
            /swc root/intBehSwc2/run21
          </START-ON-EVENT-REF>
          <OPERATION-IREF>
            <P-PORT-PROTOTYPE-REF DEST="P-PORT-PROTOTYPE">
              /swc root/swc2/pport1
            </P-PORT-PROTOTYPE-REF>
            <OPERATION-PROTOTYPE-REF DEST="OPERATION-PROTOTYPE">
              /interfaces/CS string to int/parse
            </OPERATION-PROTOTYPE-REF>
          </OPERATION-IREF>
        </OPERATION-INVOKED-EVENT>
      </EVENTS>
      <RUNNABLES>
        <RUNNABLE-ENTITY>
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          <CAN-BE-INVOKED-CONCURRENTLY>true</CAN-BE-INVOKED-CONCURRENTLY>
          <SYMBOL>run21</SYMBOL>
        </RUNNABLE-ENTITY>
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          <SHORT-NAME>run22</SHORT-NAME>
          <CAN-BE-INVOKED-CONCURRENTLY>false</CAN-BE-INVOKED-CONCURRENTLY>
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              <SHORT-NAME>dra1</SHORT-NAME>
              <DATA-ELEMENT-IREF>
                <R-PORT-PROTOTYPE-REF DEST="R-PORT-PROTOTYPE">
                  /swc root/swc2/rport1
                </R-PORT-PROTOTYPE-REF>
                <DATA-ELEMENT-PROTOTYPE-REF DEST="DATA-ELEMENT-PROTOTYPE">
                  /interfaces/SR Int16/intValue1
                </DATA-ELEMENT-PROTOTYPE-REF>
              </DATA-ELEMENT-IREF>
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            <DATA-RECEIVE-POINT>
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                </R-PORT-PROTOTYPE-REF>
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                  /interfaces/SR Int16/intValue2
                </DATA-ELEMENT-PROTOTYPE-REF>
              </DATA-ELEMENT-IREF>
            </DATA-RECEIVE-POINT>
          </DATA-RECEIVE-POINTS>
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        </RUNNABLE-ENTITY>
      </RUNNABLES>
      <SUPPORTS-MULTIPLE-INSTANTIATION>false</SUPPORTS-MULTIPLE-INSTANTIATION>
    </INTERNAL-BEHAVIOR>
    <IMPLEMENTATION>
      <SHORT-NAME>implSwc1</SHORT-NAME>
      <BEHAVIOR-REF DEST="INTERNAL-BEHAVIOR">/swc root/intBehSwc1</BEHAVIOR-REF>
      <CODE-DESCRIPTOR>
        <SHORT-NAME>src</SHORT-NAME>
        <TYPE>SRC</TYPE>
      </CODE-DESCRIPTOR>
      <PROGRAMMING-LANGUAGE>C</PROGRAMMING-LANGUAGE>
    </IMPLEMENTATION>
    <IMPLEMENTATION>
      <SHORT-NAME>implSwc2</SHORT-NAME>
      <BEHAVIOR-REF DEST="INTERNAL-BEHAVIOR">/swc root/intBehSwc2</BEHAVIOR-REF>
      <CODE-DESCRIPTOR>
        <SHORT-NAME>src</SHORT-NAME>
        <TYPE>SRC</TYPE>
      </CODE-DESCRIPTOR>
      <PROGRAMMING-LANGUAGE>C</PROGRAMMING-LANGUAGE>
    </IMPLEMENTATION>
  </ELEMENTS>
</AR-PACKAGE>
```

In RAWFP

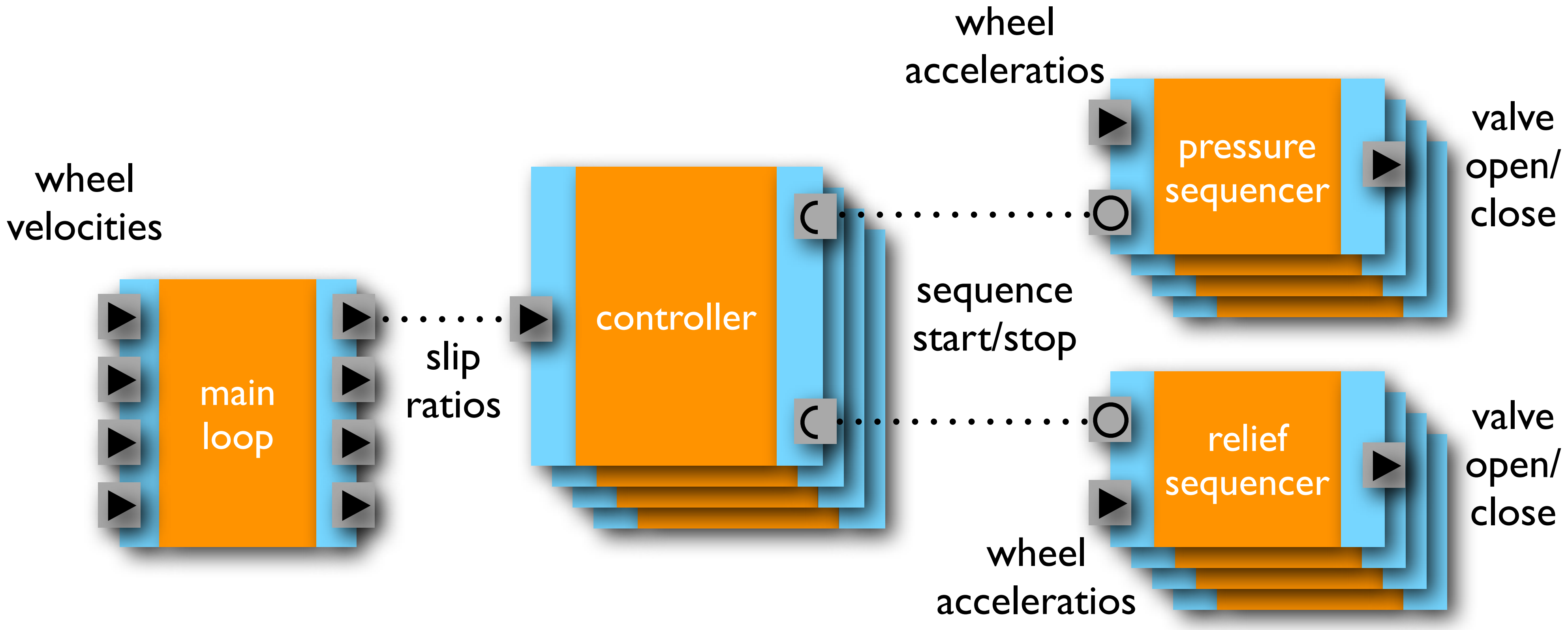
```
swc1 =  component $ do
      pport1 <- providedDataElement
      rport1 <- requiredOperation
      runnable (MinInterval 0) [Timed 0.1] (run11 pport1)
      runnable (MinInterval 0) [Timed 0.05] (run12 pport1 rport1)
      return (pport1, rport1)

swc2 = component $ do
      rport2 <- requiredDataElement
      pport2 <- providedOperation
      serverRunnable Concurrent [pport2] run21
      runnable (MinInterval 0) [Timed 0.05] (run22 rport2)
      return (pport2, rport2)

root = do
      (pdata,rop) <- swc1
      (pop,rdata) <- swc2
      connect pdata rdata
      connect rop pop
```

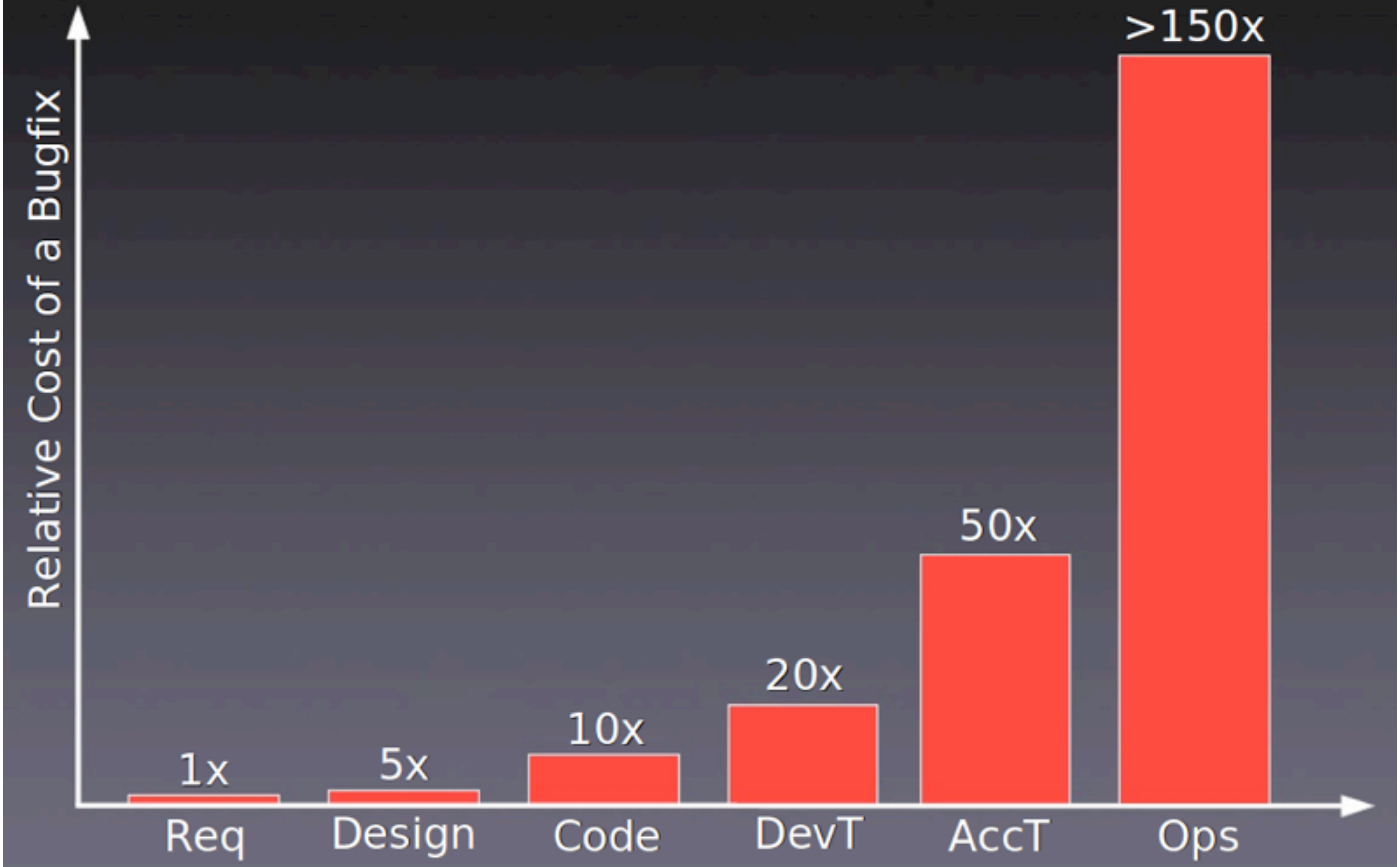
In RAWFP

```
swc1 =  component $ do
    pport1 <- providedDataElement
    rport1 <- requiredOperation
    runnable (MinInterval 0) [Timed 0.1] (run11 pport1)
    runnable (MinInterval 0) [Timed 0.05] (run12 pport1 rport1)
    return (pport1, rport1)

swc2 = component $ do
    rport2 <- requiredDataElement
    pport2 <- providedOperation
    serverRunnable Concurrent [pport2] run21
    runnable (MinInterval 0) [Timed 0.05] (run22 rport2)
    return (pport2, rport2)

root = do
    (pdata,rop) <- swc1
    (pop,rdata) <- swc2
    connect pdata rdata
    connect rop pop
```

```
run11 pport1 = do
    ...
    rte_write pport1 val
    ...

run12 pport1 rport1 = do
    ...
    val2 <- rte_call rport1 val1
    ...
    rte_write pport1 val2

run21 arg = do
    ... arg ...
    ...
    return res

run22 rport2 = do
    ...
    val <- rte_read rport2
    ...
```

An ABS system





Sources: Stefan Priebsch, Advanced OOP and Design Patterns, Barry Boehm "EQUITY Keynote Address", March 19th, 2007

AUTOSAR

- A vendor-independent software architecture standard for the automotive industry
- Platform-independent application layer
- Standardized APIs / Basic Software modules
- Standardized system constraint formats
- Extensive tool support for semi-automatic system configuration and code generation
- A detailed design-step methodology

An AUTOSAR DSEL
Why?

1. *The importance of Swedish automotive industry*
   - 110 000 people employed, 12% of export value, 25% of manufacturing industry R&D, 13% of industrial investments (2012) (2008)
   - 40% of modern car production costs pertain to electronics & software
   - Software amounts to 50-70% of electronic system development costs

An AUTOSAR DSEL
Why?

2. *The specific problem of testing automotive software*

   - > 70 ECUs, 5 busses, > 10 000 000 lines of code
   - Tight integration and interdependencies between subsystems, one single "automotive application"
   - Security concerns ⇒ mandatory resource awareness ⇒ platform dependencies ⇒ desktop testing unrealistic
   - Full-scale testing on a real moving car is both costly and impractical

An AUTOSAR DSEL
Why?

3. The gaps in AUTOSAR's behavioral modeling

- AUTOSAR only specifies program structure & APIs
- *Functional behavior* is assumed to be given in Matlab/ Simulink or as plain C code
- Software components are also expected to map onto OS tasks and low-level concepts, and the standard makes no clear separation of these abstraction levels
- Testing/simulation of *models* rather than code is thus not supported by AUTOSAR

An AUTOSAR DSEL
Why?

4. *The daunting AUTOSAR standard specification*

   - Counting ~100 documents, ~12 500 pages
     (plus just as much auxiliary material)
   - ~20 documents relate to software components, with ~1600 pages in just the two primary ones
   - The contents define a complex programming model, with subtle and sometimes unclear semantic detail

An AUTOSAR DSEL
Why?

5. *The challenges of concurrency, distribution & real-time*
   - Automotive specifics aside, the construction of concurrent, distributed & real-time software is far from a mature field
   - A technology improvement in any of these dimensions is a contribution in itself

The *RAWFP* AUTOSAR DSEL

- Combines

  1. The structure of AUTOSAR software components
  2. The API of AUTOSAR's run-time environment (RTE)
  3. The functional behavior of its host language Haskell

- Formalizes

  a) The RTE semantics (concurrency, interaction & timing)

  b) Component scoping and encapsulation

  c) The potential meaning of AUTOSAR system constraints

The *RAWFP* AUTOSAR DSEL

- Current achievements:
    - A simulator executing AUTOSAR systems defined entirely on the software component level
    - A modular scheduling architecture, including a fully randomized scheduler option
    - Integration with QuickCheck (with trace shrinking)
    - Prototype C code generation
- *Caveat: work is very much in progress!*

Outlook

- Next steps:
  - Extending the AUTOSAR standard coverage
  - Improving simulator efficiency
  - Integrating code generation with industrial tools
  - Assembling and reporting semantic ambiguities found
- Long-term goals:
  - To provide a tool for truly high-level modeling and simulation of automotive software systems
  - To fully automate the translation of models to executable AUTOSAR code