The Core NSP Type System

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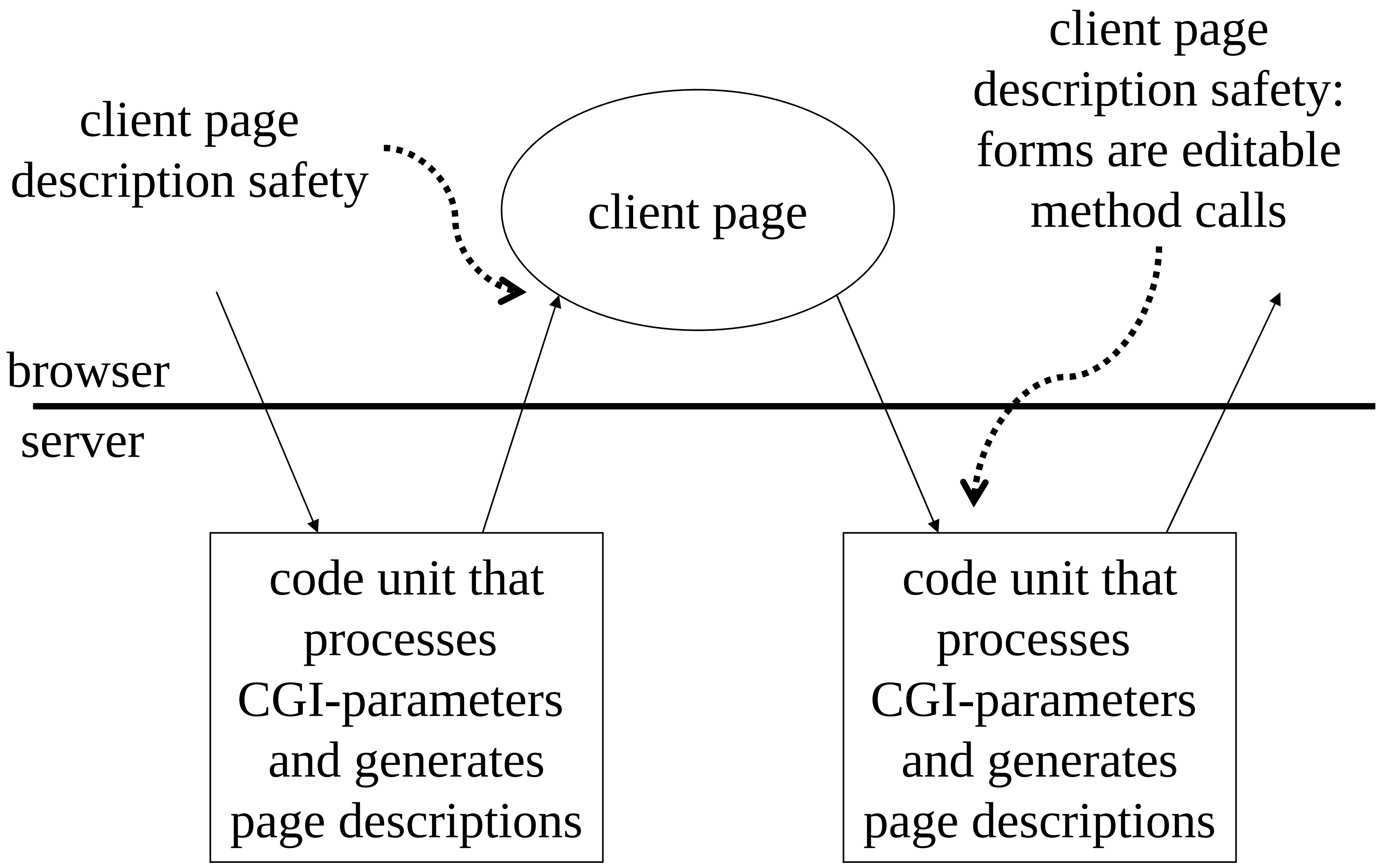
Server Pages Safety Problems


client page description safety
client page
client page description safety: forms are editable method calls
browser
server
code unit that processes CGI-parameters and generates page descriptions
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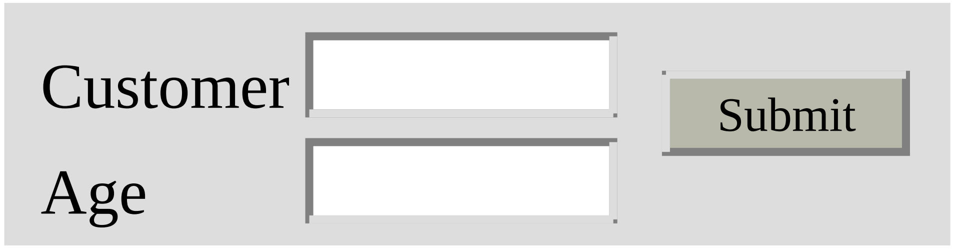
JSP Counter Example

```
<FORM ACTION="http://www.x.net/NewCustomer.jsp" method="GET">
  <%
  for (int i=0; i<j; i++) {%>
  <INPUT TYPE="TEXT" NAME="customer" SIZE="20"> <%}%>
  <INPUT TYPE="TEXT" NAME="age" SIZE="20">
  <%
  if (d==0) {%>
</FORM> <%}%>
```



NewCustomer.jsp

```
String name;
int age;
name = request.getParameter("foobar");
name = request.getParameter("customer");
try {
age = new Integer(request.getParameter("age")).intValue();
} catch (IllegalArgumentException _e){}
```

NSP – Parameterised Server Pages

```
<nsp name="Registration"><head>...</head><body>
  <form callee="NewCustomer">
    <input widget="String" param="customer"></input>
    <input widget="int" param="age"></input>
    <submit></submit>
  </form>
</body></nsp>

<nsp name="NewCustomer"><head><title>...</title></head>
  <param name="customer" type="String"/>
  <param name="age" type="int"/>
  <java>import myBusinessModel.CustomerBase;</java>
  <body>
    <java>
      CustomerBase.createCustomer(customer,age);
    </java>
    <redirect callee="Somewhere"></redirect>
</body></nsp>
```

NSP Features

- Parameterised server pages
- Support for complex types in forms
- Exchanging objects across web interaction
- Higher-order server pages
- Statically ensured client page description safety
- Statically ensured client page type safety
- No unresolved links
- Active controls
- Unifying client-side and server-side calls

NSP Type System

- Core NSP
- Core NSP Grammar
- Core NSP Types
- Core NSP Subtyping
- Type Operator: signature connection
- Core NSP Typing
- Theorem: Core NSP type checking is decidable
  - Core NSP is explicitly typed
  - Recursive subtyping is decidable

Core NSP Grammar

```
system ::= page | system system
page ::= <nsp name="id"> websig-core </nsp>
websig-core ::= param websig-core | webcall | include
param ::= <param name="id" type="parameter-type"/>
webcall ::= <html> head body </html>
head ::= <head><title> strings </title></head>
strings ::= ε |  string strings
body ::= <body> dynamic </body>
include ::= <include> dynamic </include>

string ::= s ∈ String      id ::= l ∈ Label
parameter-type ::=   t ∈ T ∪ P
supported-type ::=   t ∈ B_supported

dynamic  ::=   dynamic dynamic | ε | string
  | ul | li |  table | tr | td
  | call |  form | object | hidden |  submit
  | input | checkbox | select | option
  | expression | code
```

Core NSP Types

- Programming language types **T**
  - basic types **B** (primitive and supported)
  - type variables **V** (including type constants)
  - array types **A**, record types **R** = **Label** $\rightarrow_{\mathbf{part}}$**T**
  - recursive types **Y** = $\{\mu\, X\,.\, R \mid X \in \mathbf{V}, R \in \mathbf{R}\}$
- Server page types
  - page types **P** = $\{w \rightarrow r \mid w \in \mathbf{W}, r \in \mathbf{C} \cup \mathbf{D}\}$
  - web signatures **W** = **Label** $\rightarrow_{\mathbf{part}}(\mathbf{T} \cup \mathbf{P})$
  - complete web page **C** = { } *complete web page type*
  - document fragment types **D** = $\mathbf{L} \times \mathbf{W}$
  - layout types **L** = $\mathbf{E} \times \mathbf{F}$
  - element types **E**=$\{\circ$ **,•,TR,TD,LI,OP**$\}$*neutral doc.t., output t.,etc.*
  - form occurrences **F** = $\{\Downarrow,\Uparrow,\Updownarrow\}$ *inside f.t., outside f.t., neutral f.t.*
  - system types **S** = $\{\Diamond\}$ *well type*

Core NSP Typing – Selected Rules I

- $d \in \textbf{string} \Rightarrow d:((\bullet, \Updownarrow),\emptyset)$
- $e:T \Rightarrow$ <hidden param=“l“>e</hidden>$:((\circ, \Downarrow),\{l \mapsto T\})$
- $T \in \mathbf{B}_{\text{supported}} \Rightarrow$ <input type=“T“ param=“l“/>$:((\bullet, \Downarrow),\{l \mapsto T\})$
- </submit>$:((\bullet, \Downarrow), \emptyset)$
- $l:w\rightarrow$, $d:((e, \Downarrow), v)$, $v<w \Rightarrow$ <form callee=“l“>d</form>$:((e, \Uparrow), \emptyset)$
- $l:w\rightarrow D$, $as:v$, $v<w \Rightarrow$ <call callee=“l“>as</form>$:D$
- $d:((\circ$ *or* $\bullet,F),w) \Rightarrow$ <li>d</li>: $((\mathbf{LI},F),w)$
- $d:((\mathbf{LI}$ *or* $\circ,F),w) \Rightarrow$ <ul>d</ul>: $((\bullet,F),w)$
- $d_1:(L_1,w_1)$, $d_2:(L_2,w_2)$, $\mathit{def}(\mathit{lub}(L_1,L_2))$, $\mathit{def}\,(w_1 \otimes w_2) \Rightarrow$
  $d_1\, d_2: (\mathit{lub}(L_1,L_2), w_1 \otimes w_2)$

Core NSP Typing – Selected Rules II

- d:D, d∈**dynamic** ⇒ <include>d</include>:∅→D
- d:((• *or* ∘**,** ⇑ or ⇕), ∅), t∈**string,** d∈**dynamic** ⇒ <html><head><title>t</title></head><body>d</body></html>: ∅→
- l:T, c:w→D**,** l ∉ *dom*(w) ⇒ <param name="l" type="T" >c: (w ∪ {l ↦ T}) → D
- l:P, c:P, c ∈**websig-core** ⇒ <nsp name="l"> c </nsp>: ◇

Core NSP Subtyping – Establishing Rules –

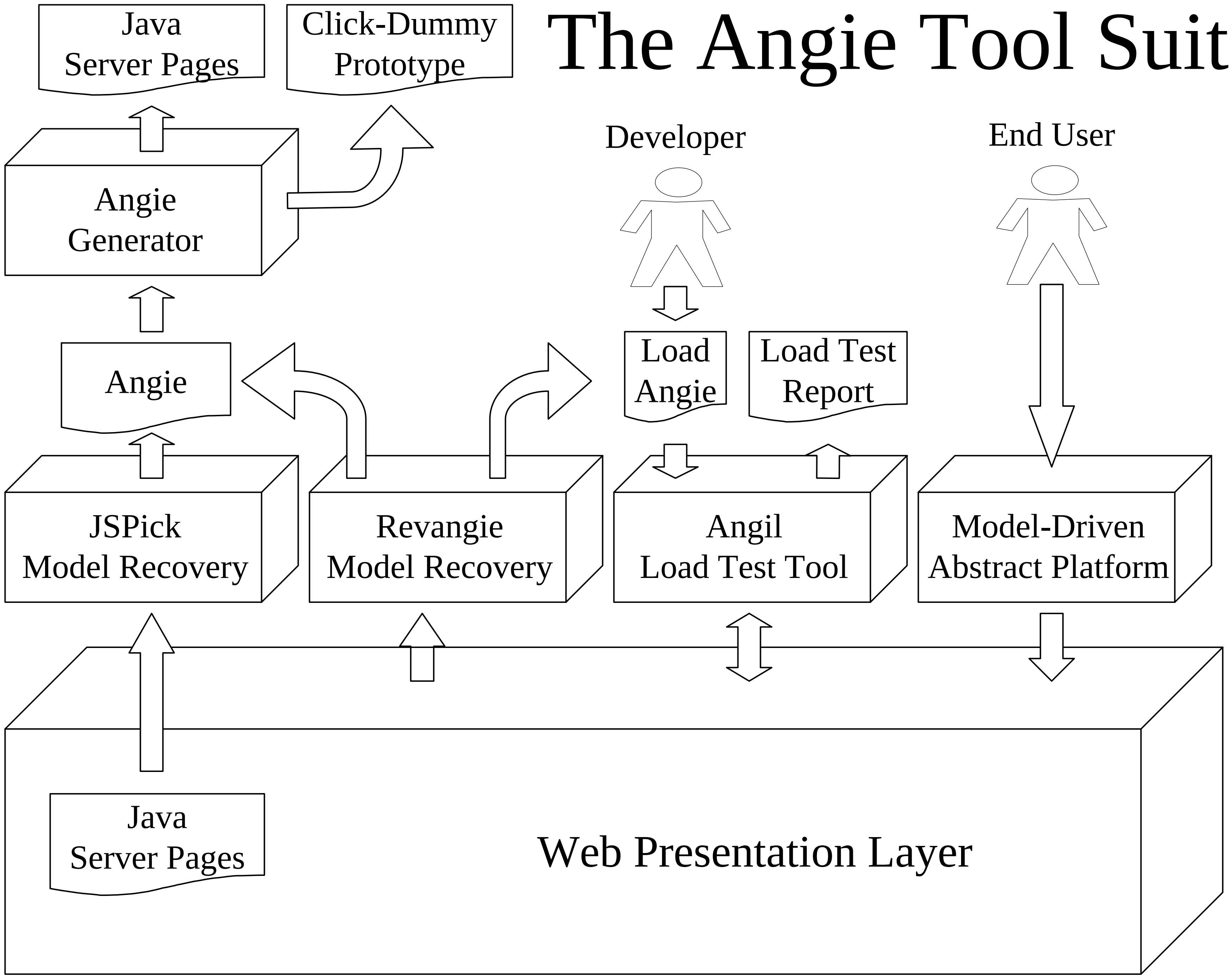
- $T < \text{array of } T$

- $T_j \notin (\mathbf{B}_{\text{primitive}} \cup \mathbf{P}),\ j \in 1..n \Rightarrow$
  $\{l_i \mapsto T_i\}^{i \in 1..j-1,j+1,..n} < \{l_i \mapsto T_i\}^{\mathbf{i \in 1..n}}$

- $\circ$ **< •,** $\circ$ **< TR,** $\circ$ **< TD,** $\circ$ **< LI,** $\circ$ **< OP**

- $\Updownarrow < \Downarrow,\ \Updownarrow < \Uparrow$

The Angie Tool Suite



Conclusion

- NSP is based on a well-understood system metaphor
- NSP ensures CPDS and CPTS at compile time
- NSP supports complex types in forms
- NSP improves web-based application architecture
- NSP seamlessly integrates with form-oriented analysis
- NSP has a convenient formal type system