Verifying Security of Web Applications

Marius Minea

joint work with Petru Florin Mihancea

Politehnica University of Timișoara
Romania

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Verifying security is important

Model checking can be done for:

- hand-written models
- binaries of actual implementations
- *models extracted from applications* (source/byte-code)

This talk: extracting models from JSP web applications

Extracting Models from Web Applications

Tool: *jModex* [Mihancea & M., CSMR-WCRE'14]
tailored to applications written using JavaServer Pages

input: user request parameters, e.g., {(name, pepi), (age, 33)}
must handle *sets* of pairs (strings)
output: generated HTML
state: session attributes, often databases

$\Rightarrow$ translate JSP code into extended finite state machine (EFSM)

EFSM Building

```
void _jspService(...) { // A component entrypoint
  String aVar = “No Link!”;
  out.println("<html>");
  out.println("<body>");
  if(request.getParameter("update").equals("false")) {
      out.println(aVar);
   } else {
      request.getSession().setAttribute("seen", "true");
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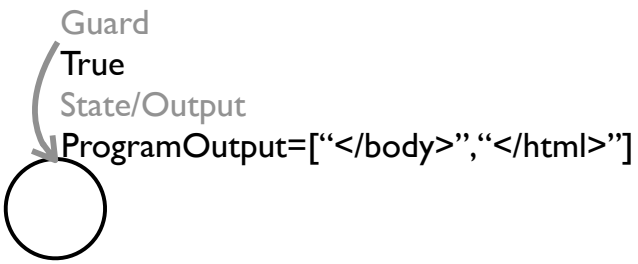

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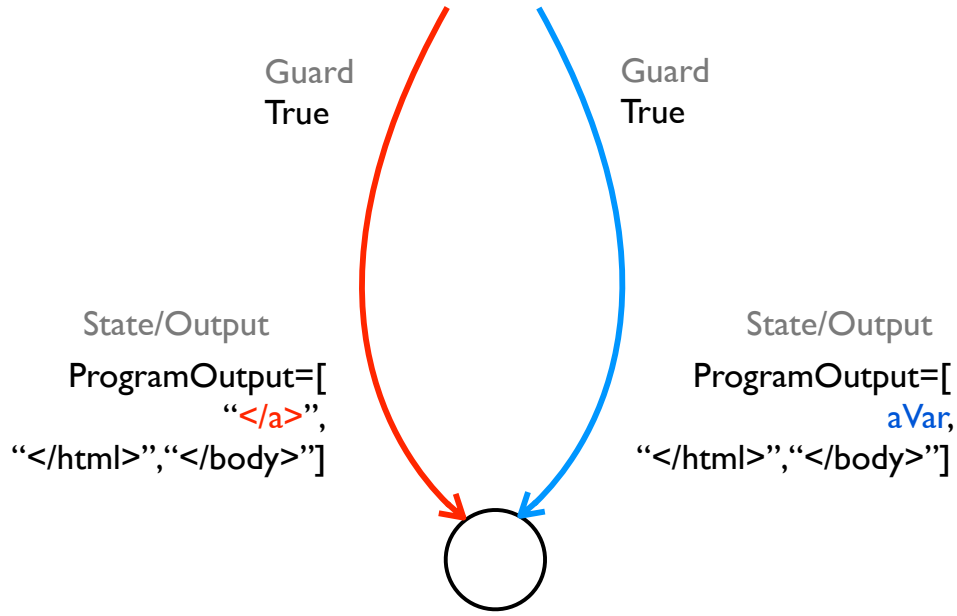

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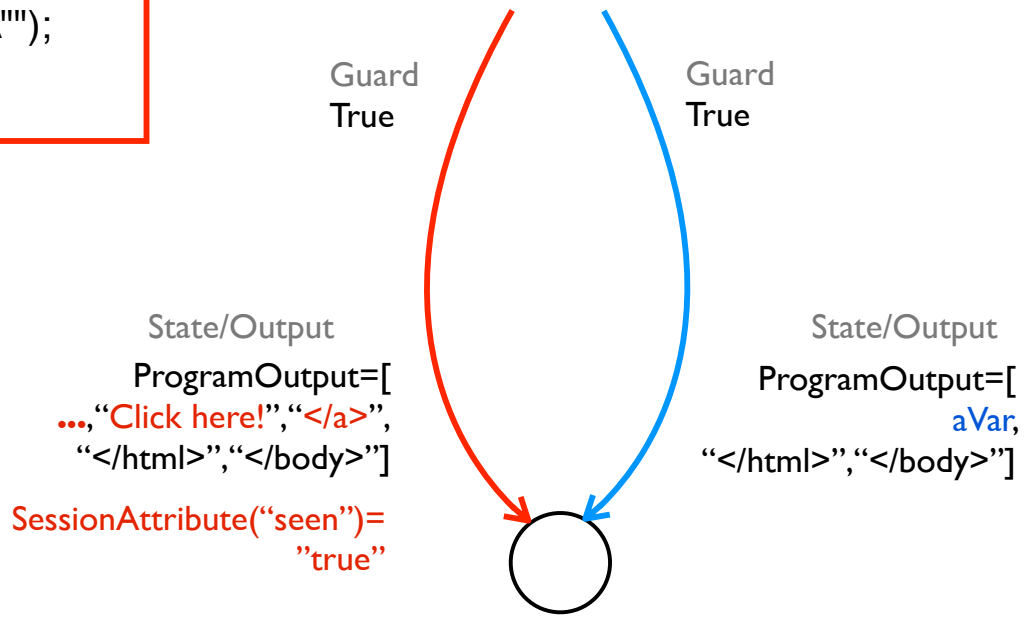

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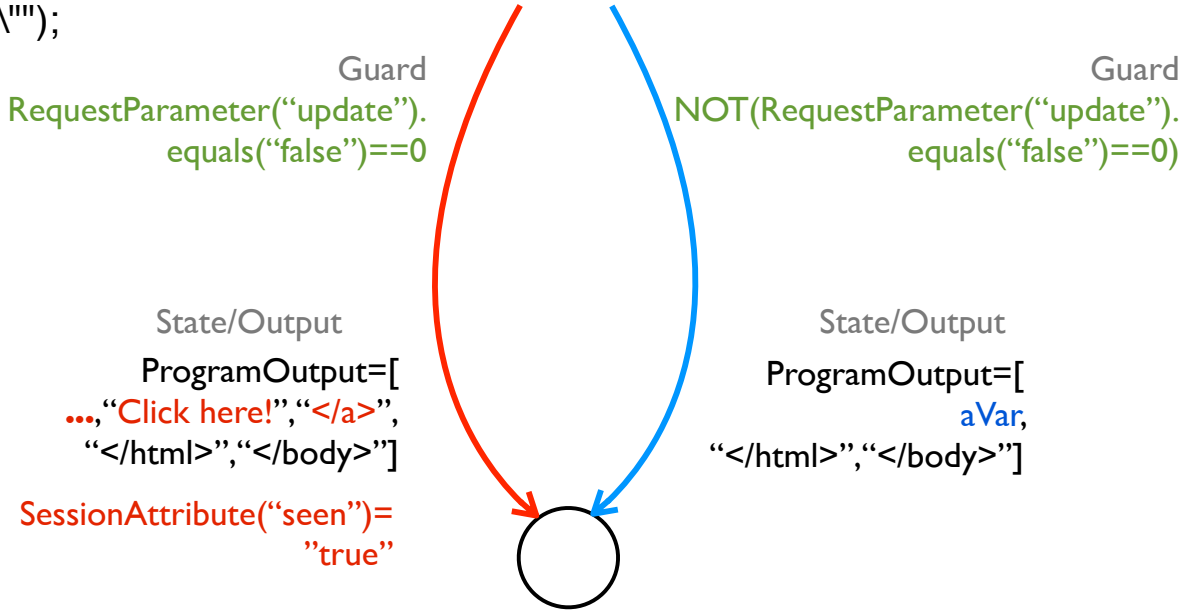

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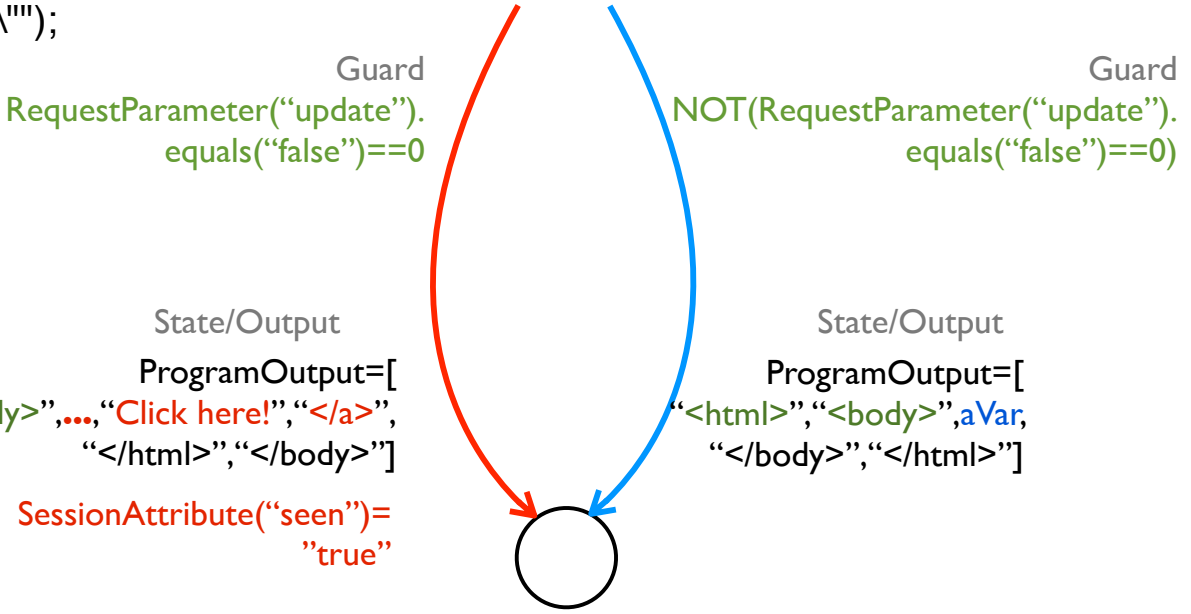

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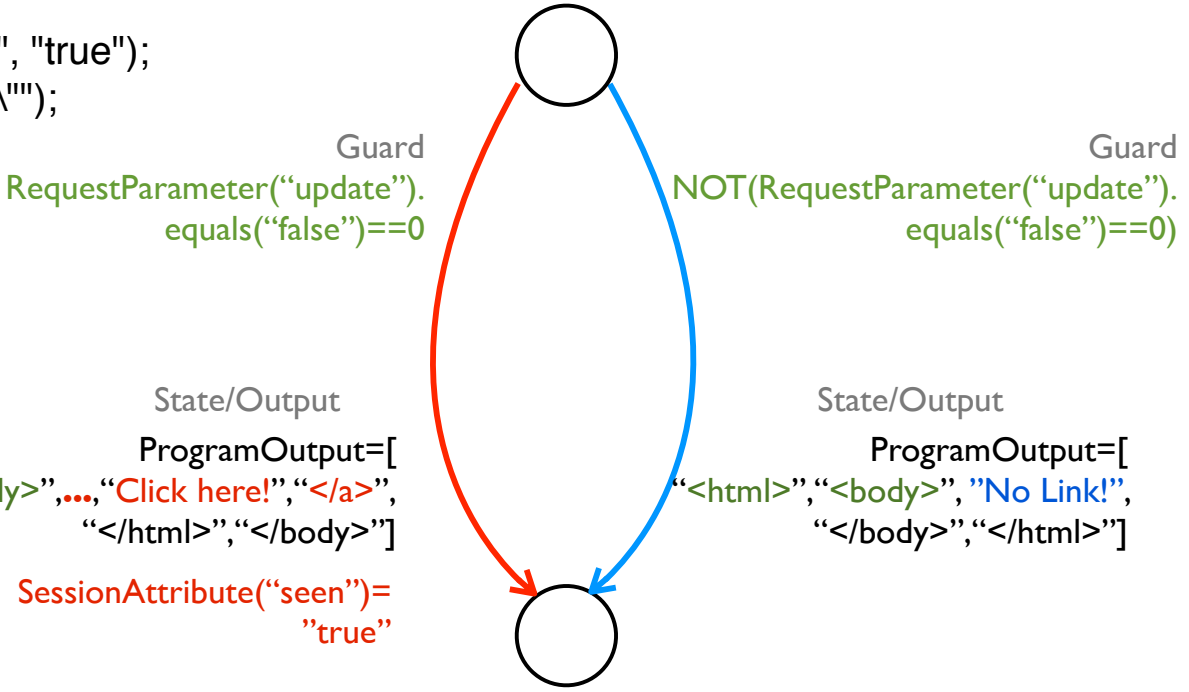

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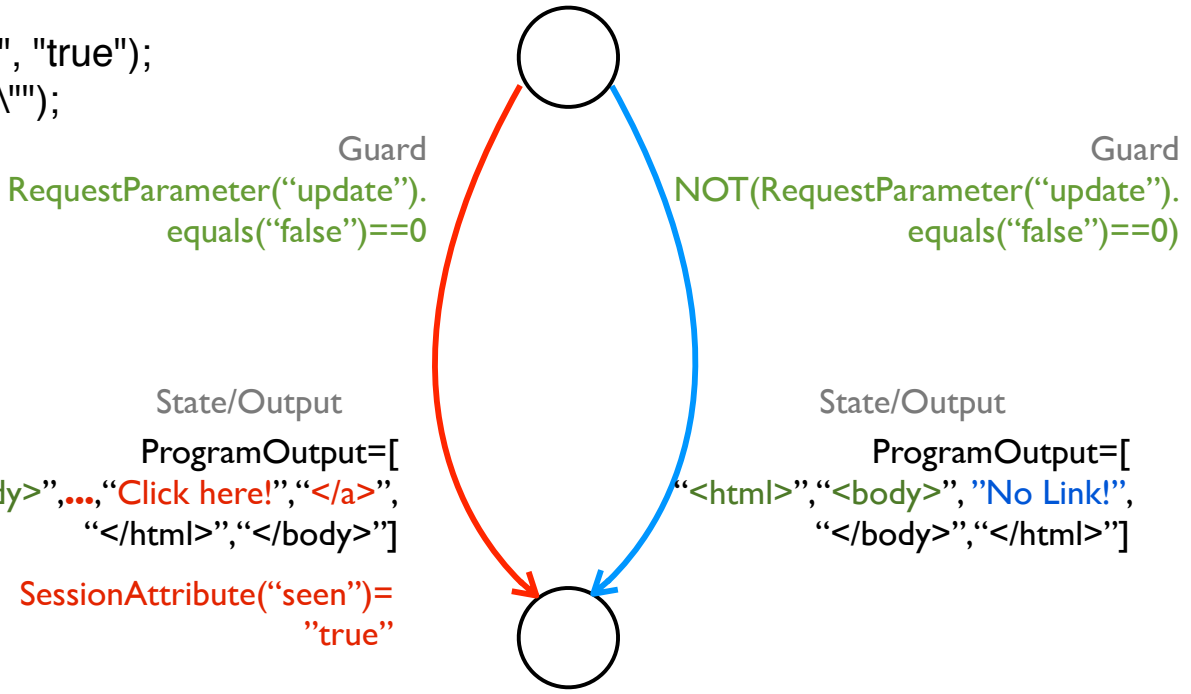


Inter-procedural

recursion not supported

Loops

state node for each loop header

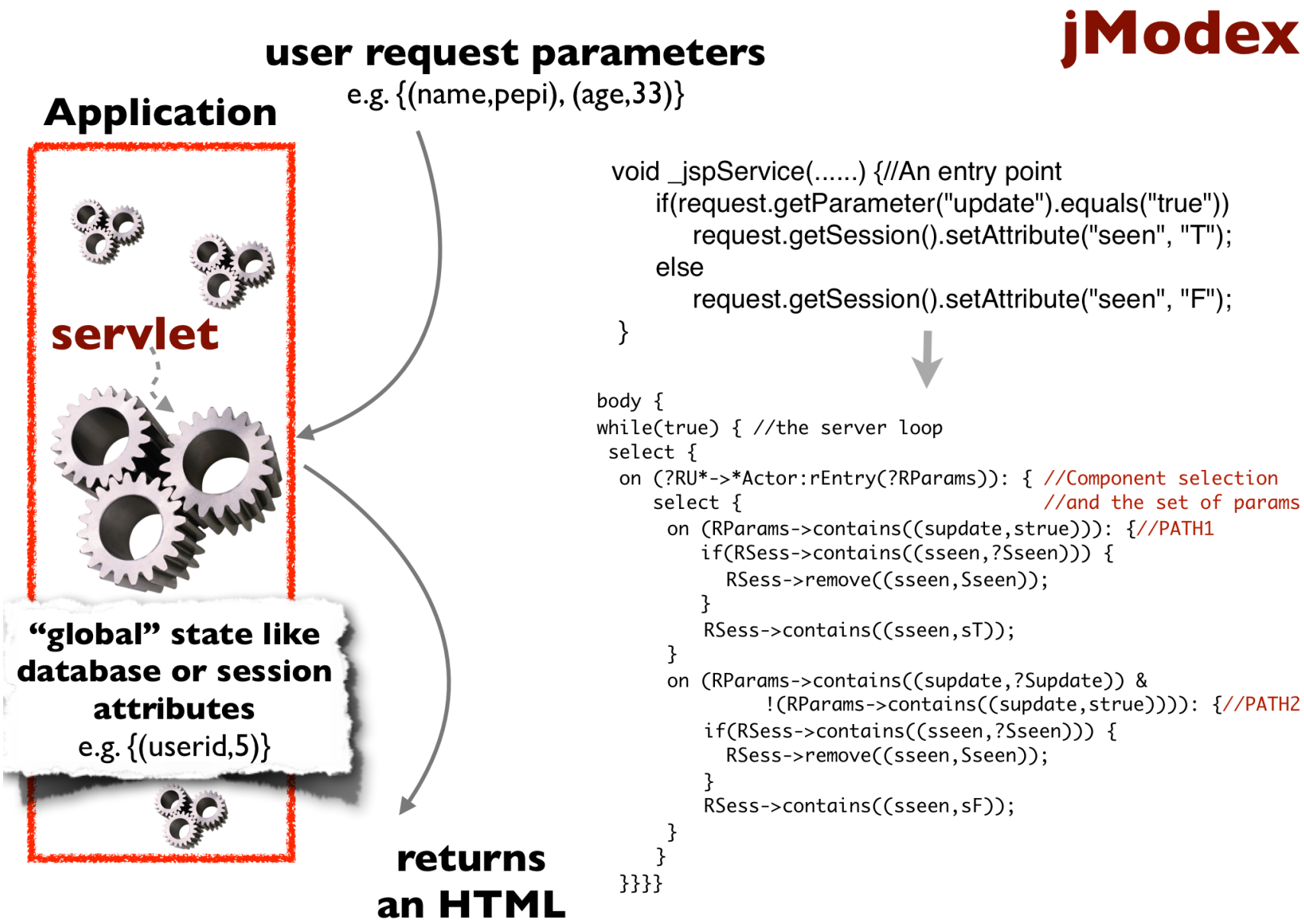
From EFSM to ASLan++ and Model Checking

jModex designed for specific language and model checkers
part of the SPaCIoS FP7 project `www.spacios.eu`
(Secure Provision and Consumption in the Internet of Services)

ASLan: low-level language with semantics based on term-rewriting
incorporating Doley-Yao intruder model
ASLan++: higher-level language, closer to usual imperative syntax

Model checkers:
CL-AtSe (Loria-INRIA), constraint logic
OFMC (IBM/ETHZ), on-the-fly
SATMC (U. Genova), sat-based

Model extraction in a nutshell



Special jModex features

Model *database operations*

needed since many applications use SQL

supports essential subset (select, update, delete, etc.)

User-specified *abstractions*

e.g. functions that can be ignored (identity)

critical to reduce model size, dependent on analysis goal

Extensible

not hard-coded for JSP, adaptable to other technologies

Case Study: GotoCode Bookstore

open-source, 28 JSPs, 22 kLOC Java code, several security checks

... and one flaw: can change any profile (incl. admin password)

Experimental Results

Simplifications used:
- ignored HTML output (irrelevant for control flow)
- ignored some sanitizing functions, assumed all parameters exist

Full bookstore code (22 kLOC)
- 90 seconds for model construction
- 600 lines ASLan++ model, 171 transition rules

For targeted flaw (change admin password):
- 2 components only, 140 lines ASLan++, 22 transition rules
- CL-AtSe model checker *finds flaw in 8 sec.*
- after code correction, model checker shows absence of flaw

Conclusions

Building analyzable models of web applications is possible
by *adapting translation to specific technologies* (e.g., JSP)

Flaws in actual applications can be found/confirmed.

Abstraction is key for obtaining models that can be handled

Next steps:

extend language support (e.g. exceptions)
more abstraction (selecting components, predicate abstraction)
optimize representation (working with sets, strings, etc.)