

Testing of inter-process communication and synchronization of ITP LoadBalancer software via model-checking

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Testing ITP LoadBalancer




VVSS 2007



**Testing of inter-process
communication and synchronization
of
ITP LoadBalancer software
via model-checking**

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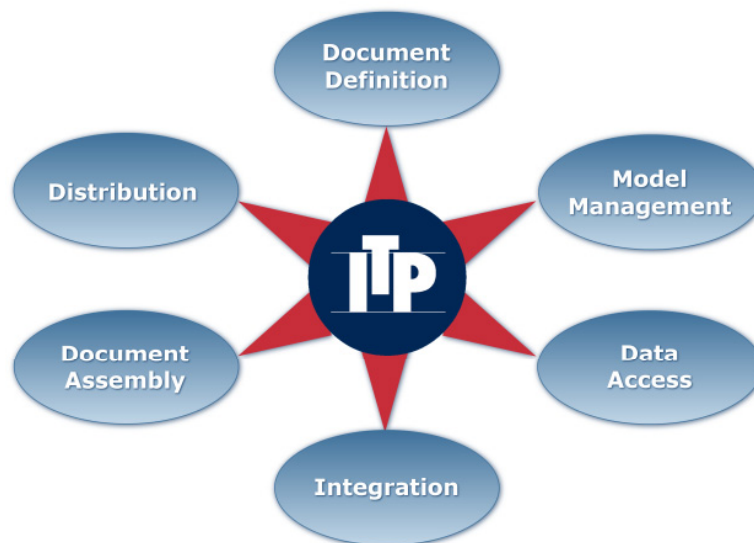
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Outline




- Aia Software and the Case Study
- Case Analysis and Reverse-Engineering
- Modeling and Analysis with the mCRL2 Toolset
- Conclusions and Open Questions









The ITP Document Platform











Applications of ITP






- Insurance**
 - Policies
 - Endorsements
 - Renewals
- Financial Services**
 - Statements
 - Correspondence
 - Contracts
- Government**
 - Taxation
 - Permits
 - Correspondence
- Independent Software Vendors**























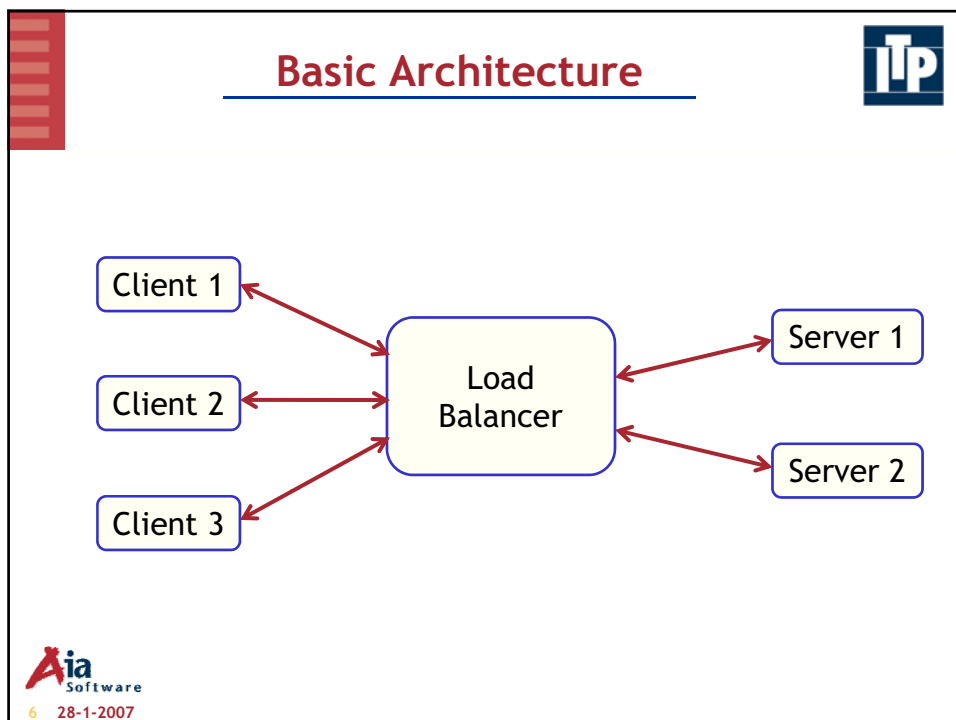





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Issues




- LoadBalancer does not respond at all (deadlocks)
- Free workers are not used (partial deadlocks)
- Client does not get a response (many reasons)



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Artifacts

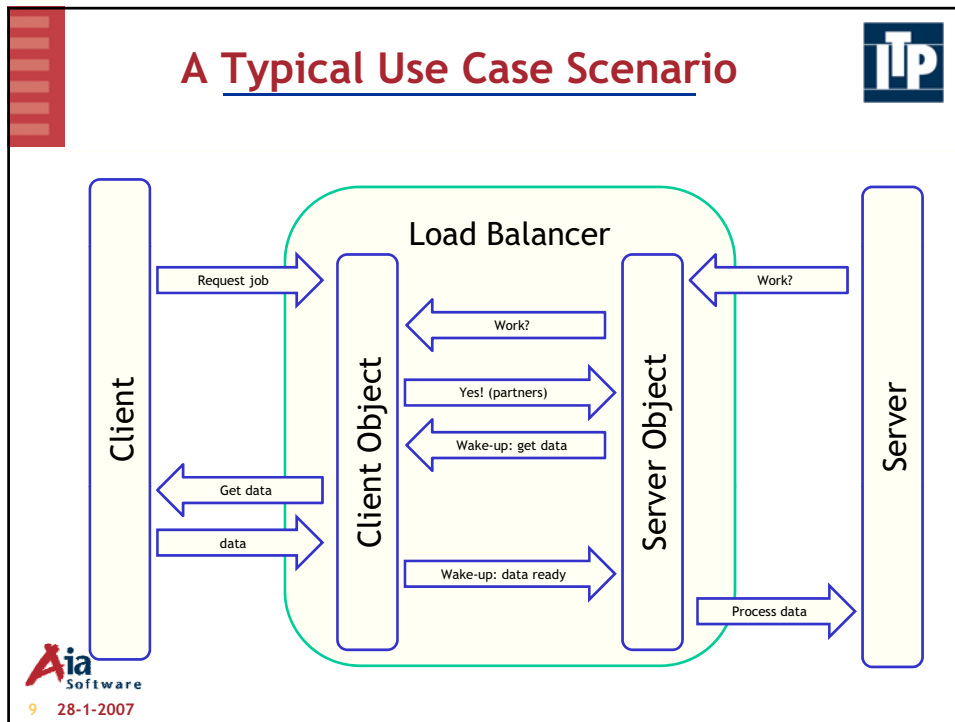



- source code in C for windows (7681 lines)
- Application layer protocol documentation
- Verbal information during meetings, phone and e-mail communication

- Threads
- MutExes
- WSA
- WaitForMultipleObjects
- Callback functions




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- ## Properties to Check
- Deadlock freedom
 - Critical logs
 - If the partner of A is $B > 0$, then the partner of B is A or 0
 - A server may not sleep w/o a partner (except when a request is pending to it)
 - Limits on locking
 - Limits on a number of requests
- 


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mCRL2 Language

- mCRL2 is based on process algebra (ACP) and algebraic (equational) data types. Specification structure:
 - data types definitions (sort, func, map, rew)
 - actions and communication functions definitions (act, comm)
 - process definitions (proc): equations involving:

$$p ::= a(\vec{t}) \mid \delta \mid Y(\vec{t}) \mid p + p \mid p \cdot p \mid p \parallel p \mid c \rightarrow p \diamond p \mid c \rightarrow p \mid \sum_{d:D} p \mid \tau_I(p) \mid \partial_H(p) \mid \rho_R(p) \mid \nabla_G(p) \mid \Gamma_C(p)$$
 - initial state (init).
- Extensions to process algebra:
 - action parameterized by data $a(d) \mid b(e) \approx (d = e) \rightarrow c(d)$,
 - $\sum_{d:D} p$ and $c \rightarrow x \diamond y$
 - systems of parameterized recursion equations.



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Experiments

- Experiments on a 3Ghz 32 bit machine with 4Gb RAM


#clients	#servers	time	#levels	#states	#transitions
1	1	7m 38s	241	657k	1.38M
1	2	3h 01m	367	18M	38.5M
2	1	9h 55m	444	54M	141M
1	3	13h*	481	213M	465.5M
2	2	> 113h*	>215	>511M	>1121M

*On a cluster of 32 64-bit machines, 1Gb each.




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Detected Issues




- partner links inconsistent
 - set partner to 0 was forgotten for one of the parties
 - found by model-code comparison
 - confirmed to be a problem by model-checking
- server sleeping w/o a partner
 1. set client's partner link to 0 before waking up the server
 2. forgotten to wake up the server
 - 1st found by model-code comparison, 2nd by model-checking
- critical logs could occur
 1. sending request for disconnect to itself happened in a wrong state (forgot to change the state)
 2. request to wake up can lead to an inappropriate state change when server disconnects (not critical)
- number of requests exceeds the limit
 - server sends request for disconnect to the client and does not break the partnership afterwards




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Conclusions




- Session layer of Load Balancer is modeled
- A number of properties are verified
- Number of issues discovered, communicated and corrected
- Cases up to 1 client and 3 servers and 2 clients and 1 server were fully analyzed
- Case with 2 clients and 2 servers was partially analyzed
- Modification of the model and further analysis are possible
- Reverse engineering of the model took most of the time




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Open questions



- How to check configuration with larger number of clients and servers
 - Optimization of process helps, but doesn't solve the problem
- Is there a sensible limit to the number of clients/servers to check?



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