Identifying Data Transfer Objects in EJB Applications

Aleksandar Pantaleev
Atanas Rountev
Ohio State University

Outline

- Background
  - DTOs in EJB applications
  - Motivation and challenges
- Dynamic analysis for DTO identification
  - Track accesses to object state in different EJB tiers
  - Implementation with JVMTI
- Experimental study
  - Real-world commercially deployed EJB application
  - Analysis cost and precision
- Conclusions and future work

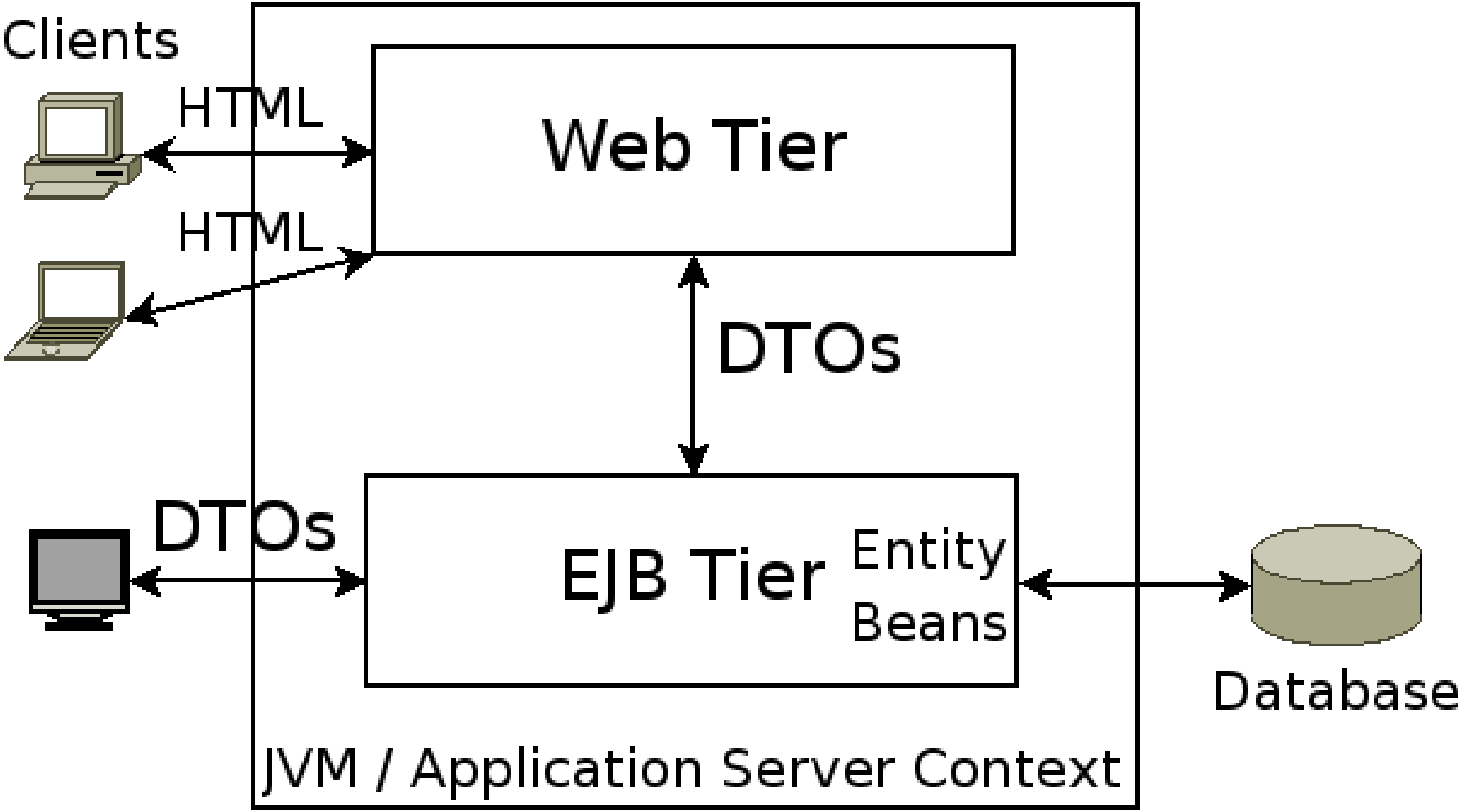
Data Transfer Objects

- DTO design pattern
  - Reduces the number of remote accesses
  - Often used in Enterprise Java software
- Goal: identify DTOs in an EJB application
  - Find classes whose instances implement the pattern
  - Approach based on dynamic analysis
- Motivation
  - Program comprehension and documentation
  - Performance optimizations
  - Software evolution (migrate from EJB2 to EJB3)

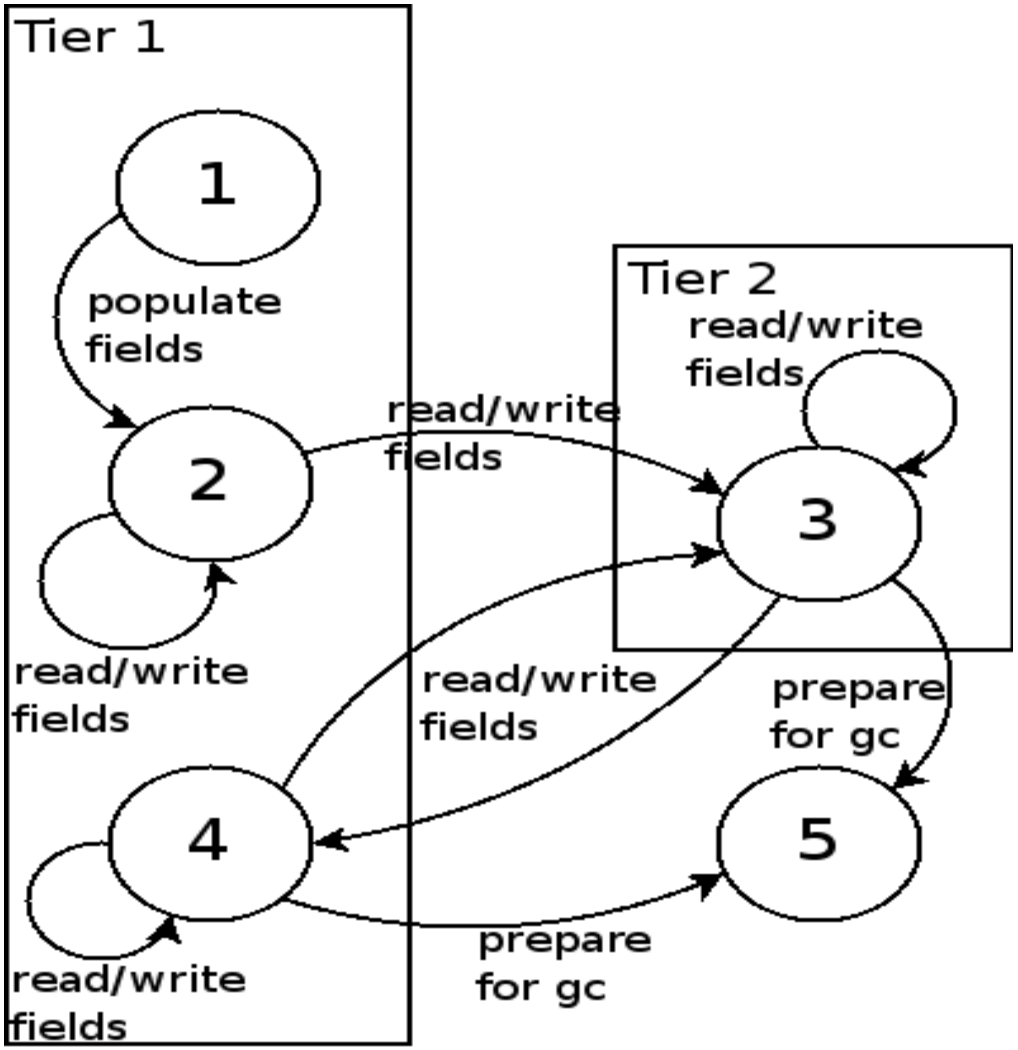
Sample DTO from the EJBCA Application

```
public class UserDataVO implements Serializable {
        private String username;
        private String subjectDN;
        private int caid;
        private String subjectAltName;
        private String subjectEmail;
        private String password;
        private int status;
        private int type;
        private int endentityprofileid;
        private int certificateprofileid;
        private Date timecreated;
        private Date timemodified;
        private int tokentype;
        private int hardtokenissuerid;
        private ExtendedInformation extendedinformation;
        public void setUsername(String user) { ... }
        public String getUsername() { ... }
        public void setDN(String dn) { ... }
        public String getDN() { ... }
         ...
}
```

Structure of an Enterprise Java Application



DTO Lifecycle



Dynamic Analysis

- Focuses on the state of objects
  - Tracks field reads & writes as opposed to method entries & exits
  - Fields of interesting (Serializable) objects tagged when the objects are created
- Matches state transitions against the DTO lifecycle
  - Requires precise identification of the EJB tier of the initiator of a state transition:
    - Handled by traversing the call stack
- Interested only in application classes
  - Robust with respect to reflection

Implementation

- JVMTI used with Java 6 JVM (agent written in C)
- JVMTI object tags used as pointers to analysis data structures
  - An object tag in JVMTI is a 32-bit integer
    - Supposed to be a user-assigned identifier
  - Agent written in C => we use that integer as a memory address
    - Cast between an integer and an address as needed
- Only interesting fields flagged as event triggers
- Garbage collection events sent only for tagged objects

Experimental Study

- EJB Certificate Authority (EJBCA) application
  - Open-source, commercially deployed
  - Comes with its own test suite
  - Multiple tiers: EJB, Web, console client, GUI desktop client
  - A total of 635 classes
- Number of classes loaded during testing
  - EJBCA's test suite was run with our JVMTI agent deployed
  - EJBCA version 3.4.1: 433
  - Application server (JBoss version 4.0.5): 1983
  - JDK version 1.6.0: 7137

Experimental Results

- 132 interesting (Serializable) clases in EJBCA code
- 13 deemed DTOs after manual inspection
- 11 of those 13 were utilized by the application's test suite (loaded in the JVM)
- Analysis precision: big picture
  - One false positive
  - One false negative

False Positive and False Negative

- False positive: not really false
  - Carries state
  - Problem is, never allows direct access to its state, so technically it is not a DTO
- False negative: wrapped by another DTO
  - True DTO
  - All reads & writes of its fields carried out through the wrapper
  - Wrapper classified as DTO, but wrapped object appears to have never moved between tiers

Run-time Performance

- Start-up overhead
  - 1m32s without agent
  - 91% overhead with full agent deployed
  - 29% overhead with dummy agent (JVMTI capabilities enabled, but all agent event handlers return immediately)
- Application overhead
  - 4m53s without agent
  - 263% overhead with full agent deployed
  - 31% with dummy agent
- Also tested with method entry & exit events
  - Start-up took ~2.5h
  - Application left overnight, had not finished

Future Work

- Improve the algorithm
  - performance
  - precision
- Migrate code: EJB2 to EJB3
  - EJB2 Entity beans are tightly coupled with DB
  - State is moved exclusively with DTOs
  - EJB3 Entity beans can be detached from the DB
  - Merge EJB2 Entity beans and their corresponding DTOs to form EJB3 Entity beans
- Identify other interesting design patterns in Enterprise Java applications
  - e.g., Data Access Object (DAO)

Questions?