Towards Safe Distributed Application Development

Patrick Th. Eugster
Sun Microsystems Software Services
Volketswil, Switzerland

Christian H. Damm
Microsoft Business Solutions
Vedb, Denmark

Rachid Guerraoui
Swiss Federal Institute of Technology
Lausanne, Switzerland
Glueing together components
- Type-safety issues at “interface”

The case of distribution and middleware
- Network inherently untyped
- How to implement “interface”
  - E.g., precompiler, language-integration (compiler), ...
- Don’t want hardwired abstraction

General-purpose programming language features for library implementations of middleware?
Roadmap

- Context
- Type-based publish/subscribe (TPS)
- TPS in a programming language
- TPS as a library
- A “futuristic” TPS library
- Comparison
- Conclusions
Publish/Subscribe

- Shared information bus, event channel
  - Multicast abstraction
  - Distributed components communicate indirectly, by
    - Publishing events (messages)
    - Subscribing to events (messages)
  - Decoupling of components

- Example application
  - Stock quote dissemination
    - Stock quotes published by stock market
    - Stock quotes subscribed to by stock brokers
TPS in Short

- **Motto**
  - Events are objects, instances of application-defined types

- **Publishing objects**
  - A copy of a published object is created for each interested subscriber

- **Subscribing to object types**
  - No explicit „subject“, the type is the subject
  - No explicit „properties“, the state is the content
    - Subscriptions expressed as predicates on public members, i.e., fields and methods
    - Subscriptions should be „migratable“
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**TPS in a Programming Language**

- Merging middleware and programming language
  - Investigate feasibility of TPS principles

- $\text{Java}_{PS}$
  - `publish` new `StockQuote(...)``;
  - `subscribe` `(StockQuote q){...}{...};`

- Implemented with extended compiler
  - Heterogenous translation
  - Generation of “adapter code” e.g., `StockQuoteAdapter`
  - Invocations of primitives transformed, performed on adapters
public class StockQuote implements ...
{
    private String company;
    private float value;
    private int amount;
    public String getCompany() {
        return company;
    }
    public float getValue() {
        ...
    }
    public int getAmount() {
        ...
    }
    public StockQuote(String c, float v, int a)
    {
        company = c;
        value = v;
        amount = a;
    }
}

- Publishing stock quotes
  StockQuote q = new StockQuote("Telco", 100.0, 25);
  publish q;

- Subscribing to stock quotes
  Subscription s =
  subscribe(StockQuote q)
  {
      return
      q.getCompany().equals("Telco");
  }
  {
      System.out.println(q.getPrice());
  }
  s.activate();
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TPS as an External Library

- First-class software bus or event channel
- Distributed Asynchronous Collections (DACs)
  - Variant of well-known collection abstraction
    
    ```java
    interface DAC extends Collection {}
    ```
  - Intuitive use, integrated with inherent Java collection framework
  - Adding an element to a DAC comes to publishing that element
  - Browsing a DAC for particular elements expresses an interest in these elements, and is interpreted as subscription
Developing with DACs

■ Publishing stock quotes

DAC qs =
   new DASet("StockQuote");
StockQuote q =
   new StockQuote("Telco",
       100.0,
       25);
qs.add(q);

■ Subscribing to stock quotes

class MySubs
   implements Subscriber {
   public void notify(Object o) {
      StockQuote q = (StockQuote)o;
      System.out.println(q.getValue());
   }
}

Accessor acc =
   new Invoke(".getCompany", null);
Condition myCond =
   new Equals(acc, "Telco");
qs.contains(new MySubs(), myCond),
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A Futuristic TPS Library

- Application-defined event types and type safety
  - A first-class channel abstraction must comply to the event type

- GDACs are parameterized by event type

```java
interface GDAC<T> extends Collection<T> {
    void add(T t);
    Subscription<T> contains(Subscriber<T> st);
    ...
}
```

- Generic Java (GJ)
  - Parametric polymorphism (F-bound polymorphism)
    - A „future“ version of the Java language (1.5)

- Subscription enables the expression of predicates
  - Behavioral reflection introduced in Java 1.3 (dynamic proxies)
Developing with GDACs

- Publishing stock quotes

GDAC<StockQuote> qs =
new GDASet<StockQuote>();
StockQuote q =
new StockQuote("Telco",
100.0, 25);
qs.add(q);

- Subscribing to stock quotes

class MyStockSubs
implements Subscriber<Stockquote>
{
    public void notify(Stockquote q) {
        System.out.println(q.getValue());
    }
}
Subscription<StockQuote> s =
    qs.contains(new MyStockSubs());
Stockquote q = s.getProxy();
q.getCompany().equals("Telco");
s.activate();
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Comparison

- **Simplicity: programming effort**
  - 1. Java$_{PS}$, 2. GDACs, 3. DACs

- **Flexibility: extension effort**
  - 1. GDACs/DACs, 3. Java$_{PS}$

- **(Type) safety: deployment**
  - 1. Java$_{PS}$, 2. GDACs, 3. DACs

- **Performance: overhead**
  - Negligible overhead of reflection
  - No overhead for genericity (type casts inserted at compilation)
Shortcomings

- No runtime support for genericity
  
  ```java
  GDAC<StockQuote> qs =
    new GDASet<StockQuote>(StockQuote.class);
  ```

- No dynamic proxies for classes
  
  ```java
  Stockquote q = s.getProxy();
  q.getCompany().equals("Telco");
  ```

- No dynamic proxies for primitive types
  
  ```java
  Stockquote q = s.getProxy();
  q.getValue() < 100.00;
  q.getCompany().equals("Telco") && ...;
  ```
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Conclusions

- **Genericity**
  - For type-safe "interface" abiding to applications
  - Should include runtime support

- **Reflection**
  - For implementation behind "interface" on top of untyped network
  - Should include structural and behavioral reflection

- **Type system**
  - Should be simple and uniform, e.g., no hybrid type system

- **TPS stringent demands**
  - Requirements include many other abstractions

- **.NET?**