Linguistic Support for Distributed Programming Abstractions

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Context

- Distributed applications
  - Built on top of “middleware”

- Implementing (type safe) middleware
  - What abstraction?
    - E.g., remote procedure call, messaging, ...
  - How to implement the “interface” between middleware and applications (depending on application types)?
    - I.e., stubs, proxies, adapters, connectors, ...
    - E.g., precompiler, language-integration (compiler), library, ...

- General-purpose programming language features for library implementation?
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
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., $\text{StockQuoteAdapter}$
  - 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

```java
StockQuote q = new StockQuote("Telco", 100.0, 25);
publish q;
```

## Subscribing to stock quotes

```java
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
    ```
    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
Publishing stock quotes

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

Subscribing to stock quotes

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

```java
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)
Publishing stock quotes

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

Subscribing to stock quotes

```java
class MyStockSubs
    implements Subscriber<Stockquote> {
    public void notify(Stockquote q) {
        System.out.println(q.getValue());
    }
}
```

```java
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. JavaPS, 2. GDACs, 3. DACs

- **Flexibility: extension effort**
  - 1. GDACs/DACs, 3. JavaPS

- **Type safety: deployment**
  - 1. JavaPS/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?**
Questions