Aspects in Android: Usability and Performance

What is aspect-oriented programming

Affecting Applications in Android Using Aspects

[illegible]

Usability of AspectJ from the Performance Perspective

[illegible]

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```
public class Point {
    private int x;
    private int y;

    public void setX(int x) { this.x = x; }
    public void setY(int y) { this.y = y; }
    public int getX() { return x; }
    public int getY() { return y; }
}
```

```
public aspect RangeControl {
    void around(int x): call(void Point.setX(..)) && args(x) {
        if (x < 0)
            proceed(640 + x % 640);
        else if (x > 640)
            proceed(x % 640);
        else
            proceed(x);
    }
}
```

A more advanced aspect

```
public aspect SomeAspect {
    void around(): call(void My*.main(*)) {
        invokeQueue.add(new Runnable() {
            public void run() {
                proceed();
            }
        }); // calls captured and sent to some queue
    }
}
```

- The Worker Object Creation object-oriented design pattern

AOP in AspectJ

- Not only calls, but executions, access to attributes, or even control flows can be captured
- Aspects can introduce new attributes and methods
- Aspects can be used to mechanize changes, which is very useful in customization
- All this is so-called asymmetric aspect-oriented programming (AOP)
- There's much more to AOP...
- Separation of crosscutting concerns
- Advanced modularization

Can aspect-oriented programming be utilized in Android?

[illegible]

Take the GPS sensor in terms of

[illegible]

Altering the GPS sensor output

[illegible]

What else can be done with aspects in Android?

[illegible]

Even more to be done with aspects in Android

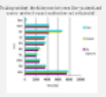
[illegible]

Our performance measurement framework (1)

- https://github.com/[illegible]/AspectJ-Performance-Measurement-Framework
- Ackermann function calculation (deep recursion)
- Fibonacci sequence calculation (branching recursion)
- Large matrix computation (matrix operations)
- Nested loop execution (loop handling)
- Random generation of double numbers (random generation)
- Prime numbers calculation (arithmetic operations)
- Text string concatenation (working with string values)
- Read of a large text file (working with I/O)
- Quicksort algorithm (sorting)
- Object instantiation (memory allocation)

Our performance measurement framework (2)

- Targeting the overhead coming from the very invocation of aspects or, more precisely, advices (before, after, and around)
- Coarse fine grained aspect application
- Tests have been performed repeatedly big number of times to decrease the imprecision of the System.nanoTime() method
- Desktop and mobile setting



Mobile setting

- Android mobile device with the ART virtual machine with a clean Android installation (9.0.0)
- Slightly altered original test suite for performance measure

Findings

- High use of aspects causes more significant performance overhead in mobile devices compared to desktop devices
- It pays off to apply aspects rather to a small number of high time complexity methods than to a large number of low time complexity methods
- The before advice generates less performance overhead than the after advice (on both mobile and desktop devices); the around advice generates the biggest performance overhead

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A more advanced aspect

```
public aspect SomeAspect {
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- The Worker Object Creation aspect-oriented design pattern

AOP in AspectJ

- Not only calls, but executions, access to attributes, or even control flows can be captured

- Aspects can introduce new attributes and methods

- Aspects can be used to modularize changes, which is very useful in customization

- All this is so-called asymmetric aspect-oriented programming (AOP)

- There's much more to AOP...

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How aspect-oriented programming can be utilized in Android?

- General, application dependent application of AOP holds for mobile applications in Android, too

- An adapted build cycle is necessary in order to utilize AspectJ under Android

- Calls to Android API can be captured and affected by aspects

- Aspects can’t modify permissions that application has declared in its manifest file

Fake the GPS sensor is turned on

```
boolean around(String provider):
    call(boolean android.location.LocationManager.
        isProviderEnabled(..)) && args(provider) {

    //Additional logic...
    return true;

}
```

Altering the GPS sensor output

- GPS consumes lots of energy
- The GSM provider's location service can be used instead
- This can be managed with an aspect that modifies location update requests

```
void around(String provider, long timeChange, float distChange,
    LocationListener listener):
    call(void android.location.LocationManager. requestLocationUpdates(
    String, long, float, android.location.LocationListener))
    && args(provider, timeChange, distChange, listener) {

    provider = LocationManager.NETWORK_PROVIDER;
    proceed(provider, timeChange, distChange, listener);

}
```

What else can be done with aspects in Android?

- Add notifications to application at any place

- Affect the Context class

- Monitor customs and routines of users (e.g., in order to increase the battery life)

- By using aspects it is possible to add notifications to application at any place

- Alter, affect, or even disable sensors

Even more to be done with aspects in Android

- Provide added functionality

- Use cases can be preserved in source code by aspects

- Disable advertisement by affecting the com.google.ads package with appropriate aspects

- Note: to disable bypassing by other applications, affect system calls, not application calls

Usability of AspectJ from the Performance Perspective

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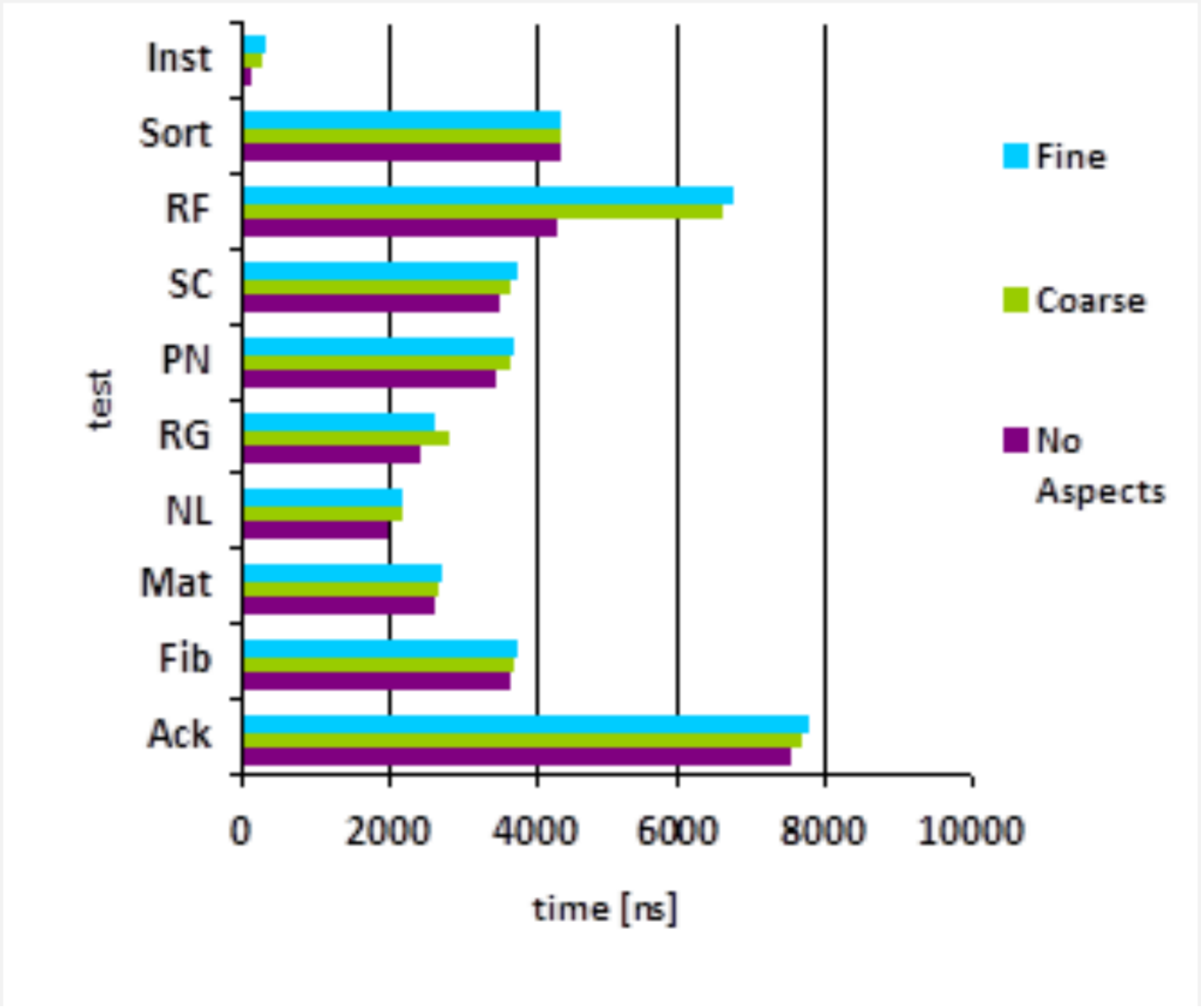
- Coarse/fine grained aspect application

- Tests have been performed repeatedly big number of times to decrease the imprecison of the System.nanoTime() method

- Desktop and mobile setting

Desktop setting: the difference between fine-grained and coarse-grained aspect application not substantial

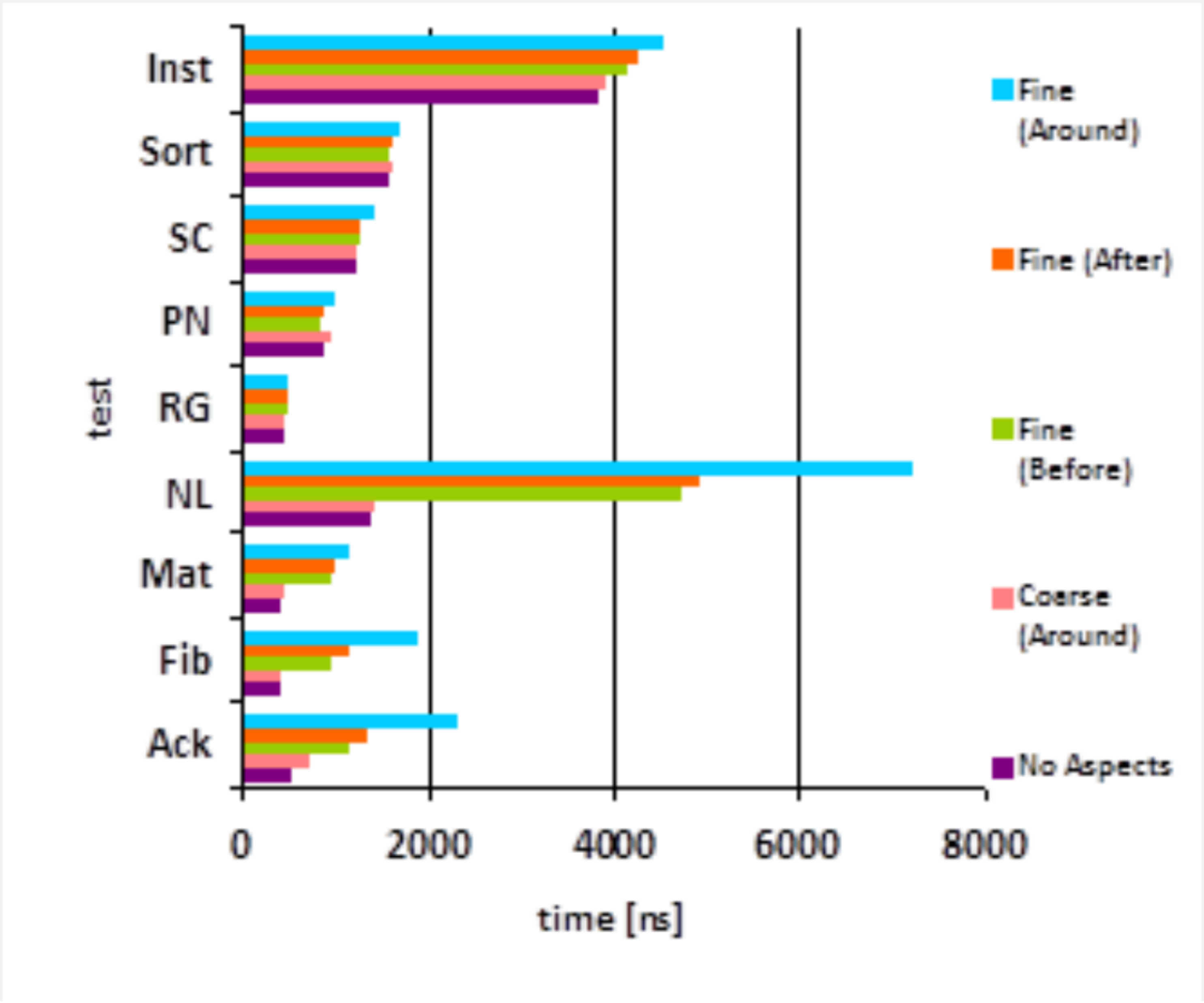


Mobile setting

- Android mobile device with the ART virtual machine with a clean Android installation (5.0.1)

- Slightly altered original test suite for performance reasons

Mobile setting (Android mobile device with AspectJ version 1.7.3): coarse-grained aspect application performs better



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