ETH zürich

Distributed Systems – HS 2017
Assignment 3

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Outline

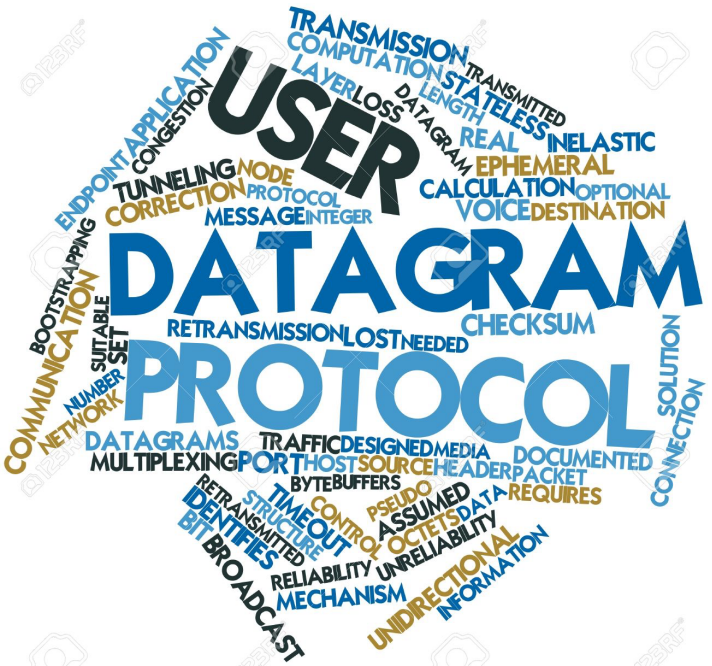
- Review of logical time and UDP
  - Causality
  - Lamport Timestamps
  - Vector Clocks

- Assignment 3

Dates:
Start: October 23, 2017
End: November 2, 2017 11:59 PM

The User Datagram Protocol

- Simple transmission model
  - No hand-shakes, ordering, data integrity
  - Datagrams can be delayed, out of order, missing

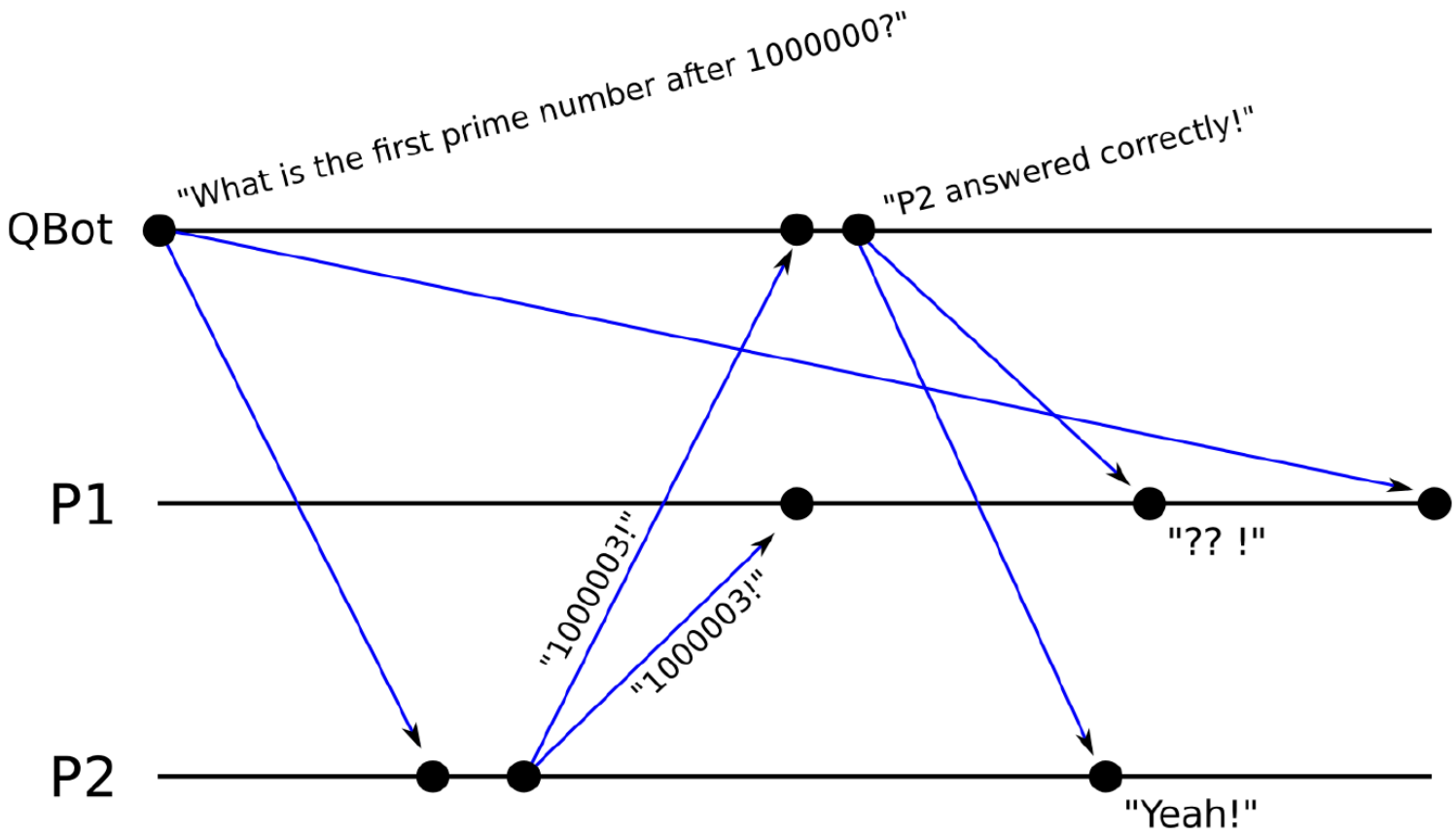


TCP vs UDP (a brief comparison)

- **Transmission Control Protocol**
- Connection oriented
- High reliability applications, time is less critical
- Heavyweight
  - Handle reliability
  - Congestion control
- Data remains intact and in the correct order

- **User Datagram Protocol**
- Connectionless
- Fast, efficient applications
- Lightweight
  - No guarantees
- No ordering of messages

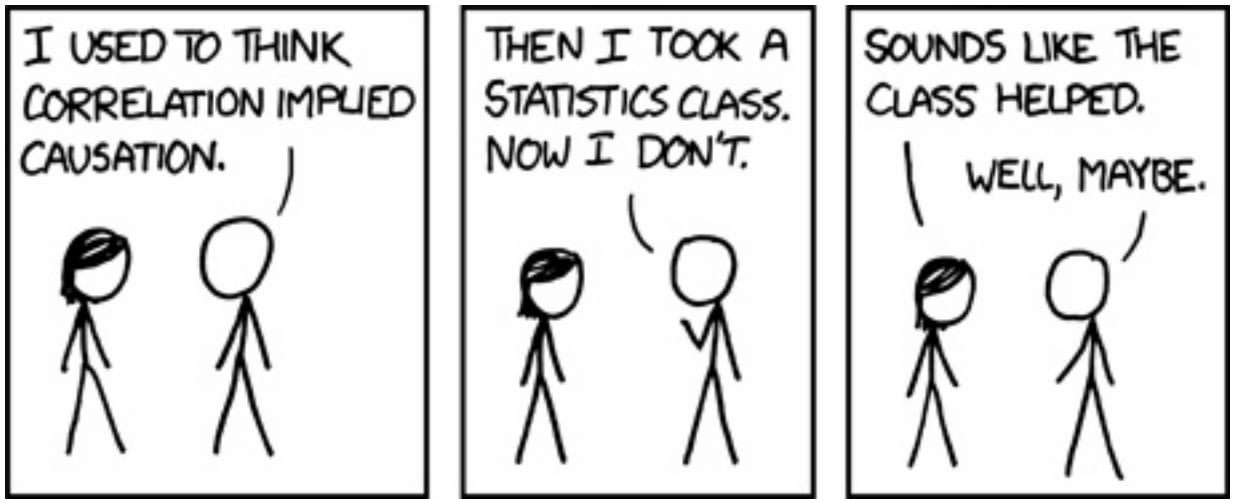
UDP Effects


"What is the first prime number after 1000000?"
"P2 answered correctly!"
QBot
P1
P2
"1000003!"
"1000003!"
"?? !"
"Yeah!"

Causality

- Interesting property in Distributed Systems
- Causal relationship **< (“happened before”)**

```
x < y iff (   (x, y on same process, x happens before y) or
              (x is sent and y is correspondingly received) or
              (transitivity) )
```



Software clocks

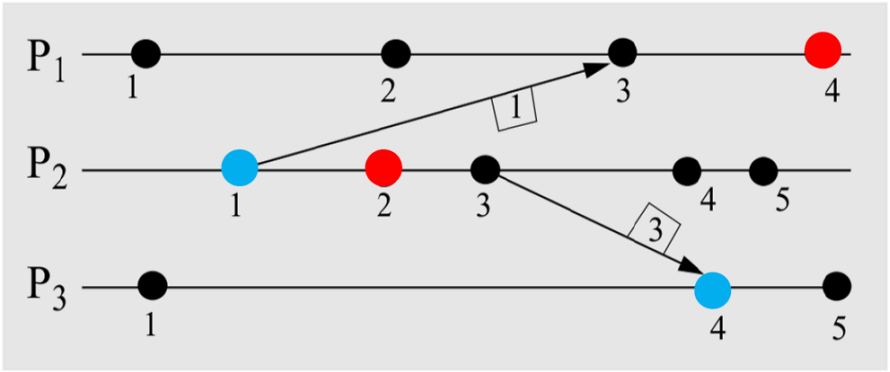
- Ideal real time
  - Transitive, dense, continuous
- No access to global clock
- Difficult to perfectly synchronize local clocks
- Logical time
  - **Lamport Timestamps**
  - **Vector clocks**
  - Matrix clocks

Lamport timestamps

- Use a single clock value
  - Local event: Local clock tick
  - Send event: Attach local clock value
  - Receive event: Max(local clock, message clock)
    First Max, then tick

- Satisfies clock consistency condition:

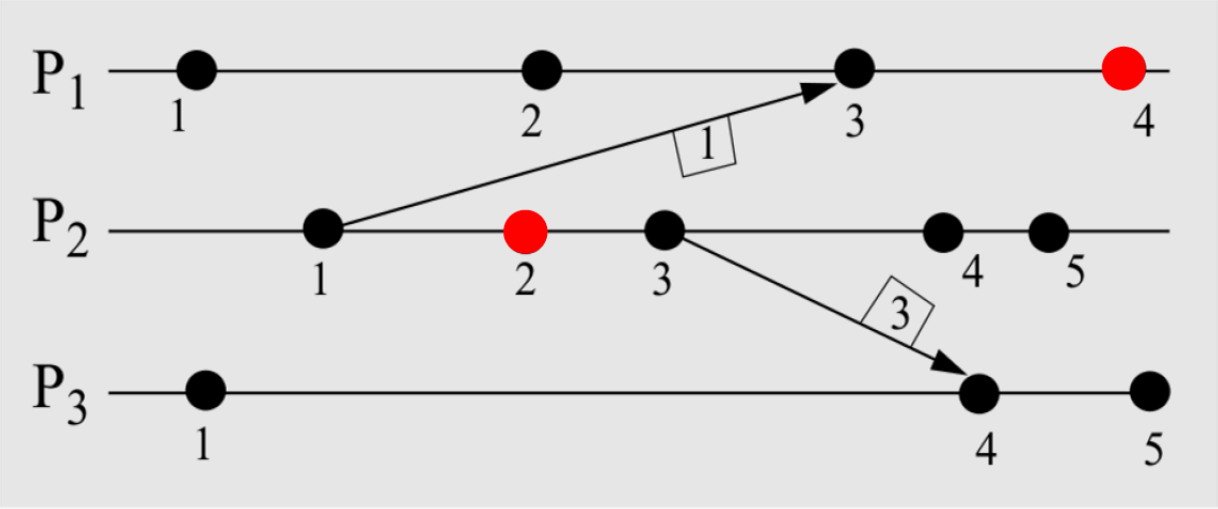
$e < e' \rightarrow C(e) < C(e')$



Lamport Timestamps

- Do **not** satisfy the **strong clock consistency condition**

$$e < e' \leftrightarrow C(e) < C(e')$$



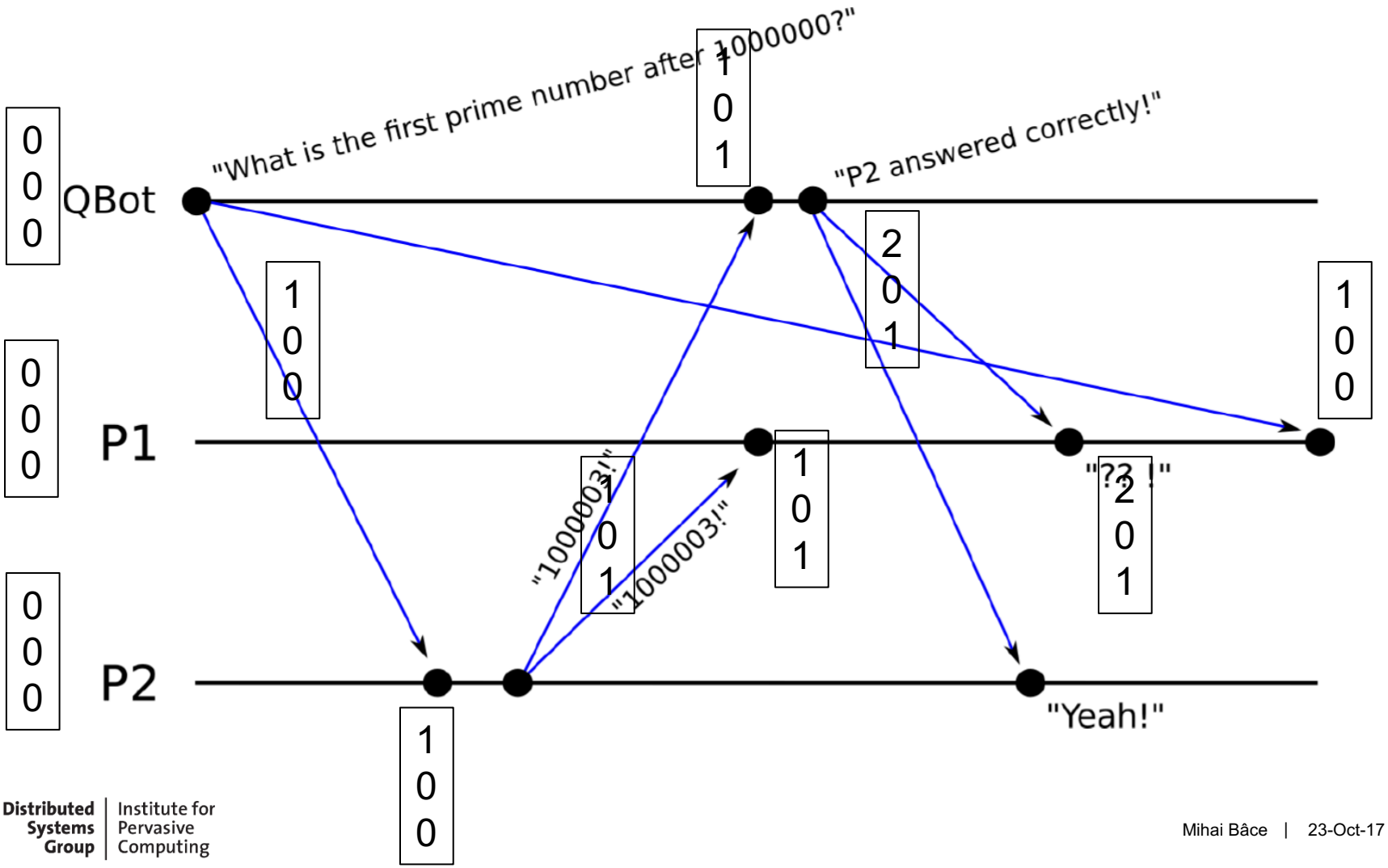
Vector Clocks

- Refinement of Lamport timestamps
- Each process keeps one counter

- **Satisfies the strong consistency condition!**

$$e < e' \leftrightarrow C(e) < C(e')$$

Vector clocks



Vector clocks

Process i stores local information on what it thinks about the local time of process (1,…,n)

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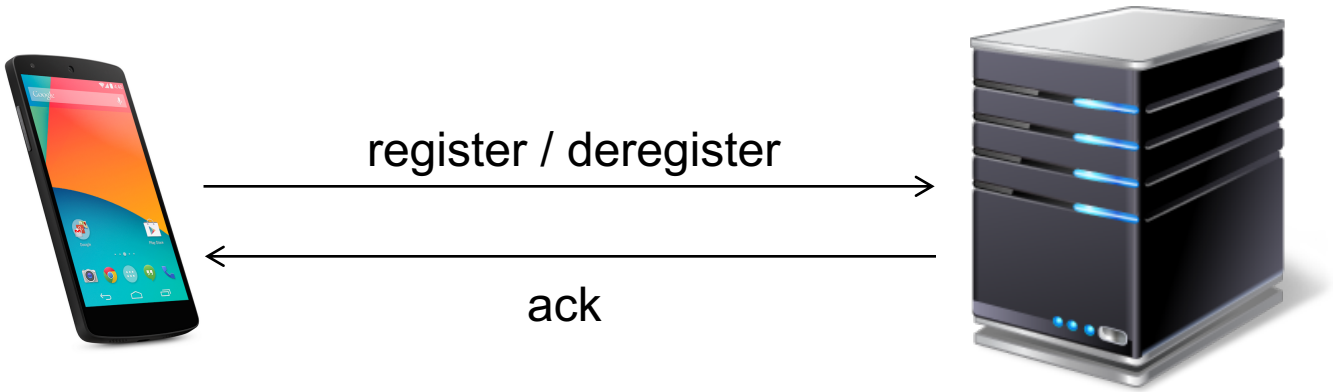
A mobile chat-like application

- Task 1: Getting familiar with Datagrams (UDP)
- Task 2: Lamport Timestamps and Vector Clocks
- Task 3: Message ordering based on Vector Clocks
- Task 4: Mini-Test

1. Getting familiar with Datagrams

- Client “registration” and “deregistration” service
- Use Datagrams
- Send message to the server, wait for acknowledgement
- Retry mechanism
  - If there is no “ack”, retry 5 times
- When successful, display a notification (e.g. Toast) and transition to a new activity



1. Getting familiar with Datagrams

Hints:

- Sending / Receiving UDP packets are network operations
- Do not use the main UI thread
  - One solution: AsyncTask
  - Careful with multiple AsyncTasks! They are executed sequentially.
- The client must always listen for received/incoming messages (up to a certain timeout)
- Receiving messages is a blocking operation!

1. Getting familiar with Datagrams - The Server

- Server will be deployed on your local machine
- Launch “chat_server.jar” from the command line

- Can use the emulator or the phones

```
java -jar chat_server.jar

Server started
Server IP address : 192.168.192.38
Server port : 4446
```

2. Implementing Lamport Timestamps and Vector Clocks

- Clock interface
- Implement all the methods
- For each type, some additional methods (check sheet)

- Use the unit tests for validation

- No server needed for this task

```
package ch.ethz.inf.vs.a3.clock;

public interface Clock{

    /**
     * Update the current clock with a new one, taking into
     * account the values of the incoming clock.
     *
     * E.g. for vector clocks, c1 = [2 1 0], c2 = [1 2 0],
     * the c1.update(c2) will lead to [2 2 0].
     * @param other
     */
    public void update(Clock other);

    /**
     * Change the current clock with a new one, overwriting the
     * old values.
     * @param other
     */
    public void setClock(Clock other);

    /**
     * Tick a clock given the process id.
     *
     * For Lamport timestamps, since there is only one logical time,
     * the method can be called with the "null" parameter. (e.g.
     * clock.tick(null).
     * @param pid
     */
    public void tick(Integer pid);

    /**
     * Check whether a clock has happened before another one.
     *
     * @param other
     * @return True if a clock has happened before, false otherwise.
     */
    public boolean happenedBefore(Clock other);

    /**
     * toString
     *
     * @return String representation of the clock.
     */
    public String toString();

    /**
     * Set a clock given it's string representation.
     *
     * @param clock
     */
    public void setClockFromString(String clock);

}
```

3. Message ordering based on Vector Clocks

- Client requests a chat log from the server
- Datagrams
  - Messages can arrive in any order. Cannot display them yet!

- Store messages in a buffer
- Order them

- Use the happened before method

3. Message ordering based on Vector Clocks

- Buffer the incoming messages in a Priority Queue
  - Priority Queue: priority heap, which orders the elements according to their natural order or according to the comparator specified at construction time
  - Use the provided implementation of the PriorityQueue from the code skeleton
- Implement a Comparator for your messages
- Every incoming message will be inserted in the correct place

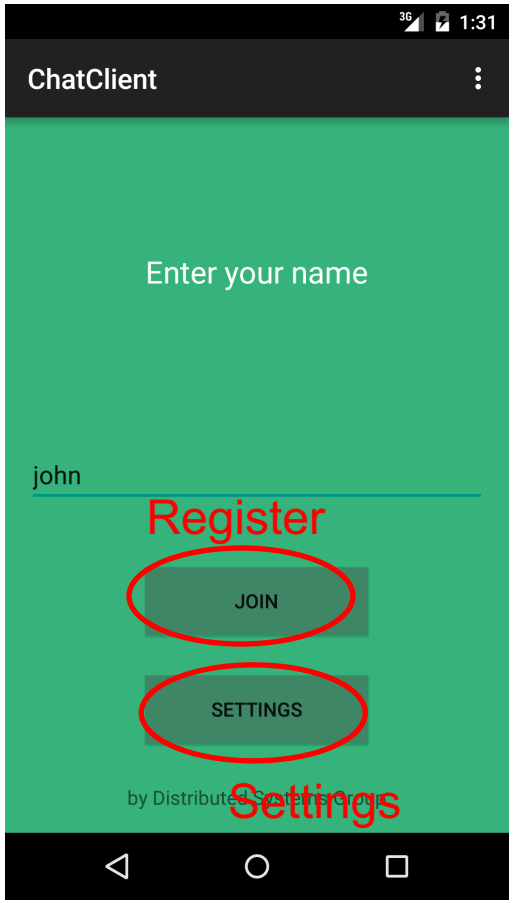
Message Structure - Sample

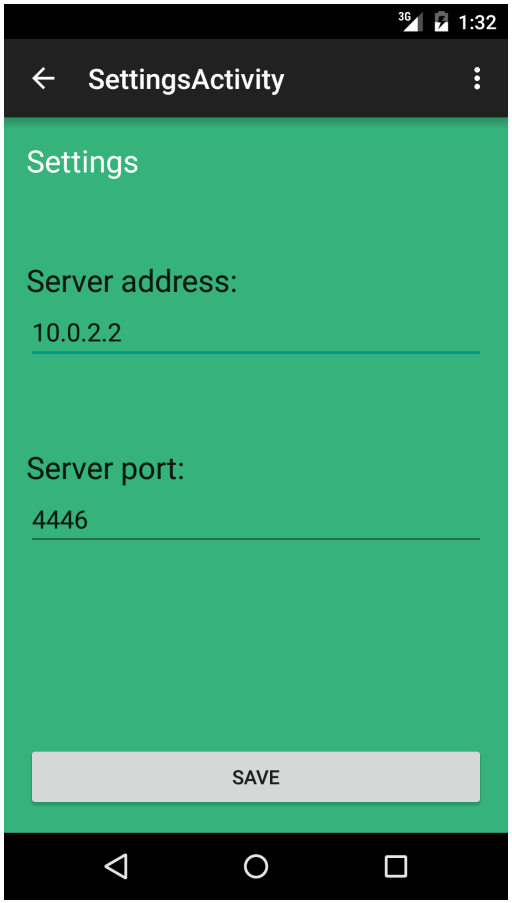
- JSON
- “header”
  - “username”: ”John” (String)
  - “uuid”: ”ae4e15ff-b589-4e85-a07c-594b16e4e645“ (String)
  - “timestamp”: "{\"0\":2,\"1\":0,\"2\":0}” (Map/HashMap for Vector Clocks)
  - “type”: “message” (String)
- “body”
  - “content”: “Hello” (String)

Message Sample

```
{
    "header": {
        "username": "server",
        "uuid": "ac31f345-a8b1-4241-b939-9d3527f14483",
        "timestamp": "{\"0\":2,\"1\":0,\"2\":0}",
        "type": "message"
    },
    "body": {
        "content":"A1"
    }
}
```

Sample Application Design

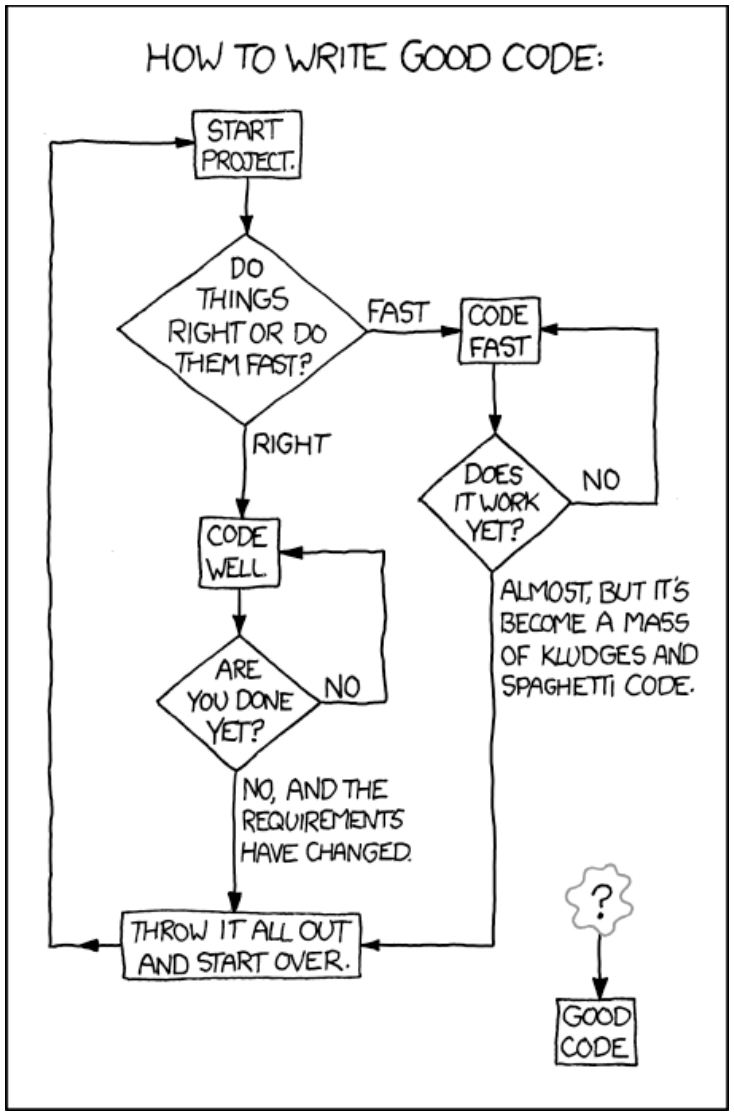




Android SDK Tools

- Android Debug Bridge (adb tool)
  - You can find the adb tool in <sdk>/platform-tools/
  - http://developer.android.com/tools/help/adb.html
- Android Emulator
  - http://developer.android.com/tools/devices/emulator.html
- Setting up a port forwarding
  - adb forward tcp:port1 tcp:port2
  - forwards the local port port1 on the machine to port2 on the emulator.
  - Example: adb forward tcp:12345 tcp:8088
- JUnit Testing
  - http://tools.android.com/tech-docs/unit-testing-support

Have fun!


HOW TO WRITE GOOD CODE:
START PROJECT.
DO THINGS RIGHT OR DO THEM FAST?
FAST
CODE FAST
DOES IT WORK YET?
NO
ALMOST, BUT IT'S BECOME A MASS OF KLUDGES AND SPAGHETTI CODE.
RIGHT
CODE WELL.
ARE YOU DONE YET?
NO
NO, AND THE REQUIREMENTS HAVE CHANGED.
THROW IT ALL OUT AND START OVER.
?
GOOD CODE