FH JOANNEUM
University of Applied Sciences

Direct Peer to Peer Communication on iOS Devices

When mediator based technology is not available

Bachelor's Thesis

submitted in conformity with the requirements for the degree of

Bachelor of Science in Engineering (BSc)

Bachelor's degree programme **Software Design and Cloud Computing**

FH JOANNEUM (University of Applied Sciences), Kapfenberg

Supervisor: DI Johannes Feiner

Submitted by: Matthias Bartholomäus

February 2025

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Abstract

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TODO: Write the abstract in English and in German, called Kurzfassung. Describe in about 250 to 350 words the problem, the innovation, the method, the results and implications.

Keywords: FHJ, SWD, thesis

Kurzfassung

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TODO: Die Kurzfassung sollte das gesamte Werk enthalten, also das spannende Problem, den gewählten – neuartigen – Lösungsansatz und natürlich vor allem die erreichten Resultate.

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1. | Introduction

> Most smartphone communication leverages one hop radio links to cell towers or WiFi access points. In recent years, however, the major smartphone operating systems have included increasingly stable and useful support for local peer-to-peer communication that allows a device to talk directly to a nearby device (using local radio broadcast) while avoiding cellular and WiFi infrastructure. The ability to create these local links, combined with the ubiquity of smartphones, enables scenarios in which large groups of nearby smartphone users run applications that create peer-to-peer meshes supporting infrastructure-free networking. There are many possible motivations for these smartphone peer-to-peer networks. For example, they can support communication in settings where network infrastructure is censored (e.g., government protests), overwhelmed (e.g., a large festival or march), or unavailable (e.g., after a disaster or at a remote event). In addition, in developing countries, cellular data minutes are often bought in blocks and carefully conserved—increasing interest in networking operations that do not require cellular infrastructure.,
>
> (Calvin Newport, 2017)

This thesis analyses and measures the capabilities of new iOS devices to communicate via local peer to peer networks. Since most of current technology standards rely heavily on external infrastructure local communication is not yet wide spread or optimized to function over long distances.

1.1. Problem Statement

Modern mobile devices can make use of a wide variety of communication technologies. To achieve data transfers seamlessly, standards like Bluetooth, WiFi or 5G need to be wireless. The use cases are different and so is the applicability and protocol. Nevertheless the complexity of creating devices supporting all of these different standards, global economic demand has drastically impacted research and development in data transmission and hardware engineering to let humanity invent smartphones. Unfortunately most of the communication methods used on smartphones all demand on mediators. Be it a router in a local network or a cell tower in a cellular network, without these nodes a connection between two peers could not be established. However in scenarios where the required infrastructure is not available or in reach, communication between two mobile phones could be initiated through Bluetooth or peertopeer WiFi. Due to the latest advancements in these technologies and hardware, it is unclear how good of an option it is to replace mediator based with direct Peer to Peer (PtP) communication in various situations. This thesis tries to find and measure metrics that indicate the quality of direct PtP connections on Apple's mobile devices. This can help to evaluate the feasibility

of alike projects. In particular the Multipeer Connectivity Framework accessible from iOS 7.0+ will be tested for its robustness considering metrics of quality in different scenarios and locations.

1.2. Research Questions

Can direct PtP connections between Apple devices improve connectivity in certain scenarios?

1.3. Hypothesis

H_1

Direct PtP connectivity on Apple devices can enhance connectivity in different scenarios.

1.4. Method

A prototype application will be developed that will serve as a tool to measure quality metrics of connectivity. The metrics will be stated in the test protocol and different scenarios will be tested that indicate different characterisics to cover most areas of application.

1.5. Summary

Since the latest smartphone technologies improved hardware and operating system for direct communications, it is unclear how well these tequniques can currently be implemented to support communication in various scenarios. Focusing on the Apple platform, an iOS App is developed, that also serves as testing utility.

2. | Related Work

Already back 2001 the Proem project (Kortuem et al. 2001) examined different aspects of peer-to-peer applications for ad hoc networks. They already noticed the trend for a ever-larger becoming applicability of personal mobile devices for data sharing but listed resources of mobile devices among other possible limitations. This facet has fastly changed since then and several new ideas like ShAir (Dubois et al. 2013), a middleware infrasructure for peer-to-peer sharing between mobile devices or mFerio (Balan et al. 2009), a peer-to-peer mobile payment system have emerged. The working group of mFerio already noticed the problem that mobile devices rely too heavily on static infrastructure. Fortunately hardware of modern smartphones has matured and has gotten support for Bluetooth, WiFi Direct and Apple's Multipeer Connectivity, which were used by Newport in his approach to develop a new gossip algorithm for a local peer to peer communication system (Newport 2017). Though approaches existed to also introduce LTE-Direct, no support for this technology is given on mobile smartphones (Gallo and Härri 2013). This is why this thesis will focus on the available technologies WiFi-Direct and Bluetooth, which work under the hood of Apple's Multipeer Connectivity.

3. | Background

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In the background section you might give explanations which are necessary to read the remainder of the thesis. For example define and/or explain the terms used. Optionally, you might provide a glossary (index of terms used with/without explanations).

Hints for equations in Typst:

Mathematical formulas are (embedded in $) in Typst. For example:

The notation used for **calculating** of *code performance* might typically look like shown in Equation 1, i.e. the first one for **slow** in Eq. I and the other one for **very slow** in Eq. II.

$$O(n) = n^2 \tag{I}$$

$$O(n) = 2^n \tag{II}$$

Equation 1: Equations calculate the performance.

In the text we refer multiple times to ϕ. We define it to be calcultated as shown here:

$$\begin{aligned} d &= 24 - 10 - 7 - \sqrt{3} \\ d &= 14 - 7 - \sqrt{3} \\ d &= 7 - \sqrt{3} \end{aligned} \tag{III}$$

$$\phi := \frac{d}{3} \tag{IV}$$

Equation 2: A custom definition of ϕ allows to shorten upcoming equations.

The Equation 2 explains (for the single steps see Eq. III and Eq. IV) how the overall ϕ is calculated to be used in the upcoming formulas of this thesis.

4. | Concept

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Describe an overall concept of a solution, which could possibly solve a given problem. Design a novel solution and visualise the architecture and relevant (data) flows. Compare and relate your approach to possible alternatives and argue why and in which way(s) the suggested solution(s) will be better.

Hints for formatting in Typst:

1. You can use built-in styles:
   1. with underscore (_) to *emphasise* text
   2. forward dash (`) for `monospaced` text
   3. asterisk (*) for **strong** (bold) text

You can create and use your own (custom) formatting macros:

1. check out the custom style (see in file `lib.typ`):
   1. `#textit` for *italic* text
   2. `#textbf` for **bold face** text

5. | Implementation

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Describe what is relevant and special about your working prototype. State how single features help to solve problem(s) at hand. You might implement only the most relevant features. Features you select from your prioritised feature list assembled in Chapter 4. Focus novel, difficult, or innovative aspects of your prototype. Add visuals such as architectures, diagrams, flows, tables, screenshots to illustrate your work. Select interesting code snippets, e.g. of somewhat complicated algorithms, to present them as source code listings.

For example, you might explain your overall system, then the details of the backend and frontend development in subsections as shown here:

5.1. Overall System

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Hints for images in Typst

Use vector graphic formats such as Scalable Vector Graphics (SVG) for drawings and png for screenshots. Using jpeg is only ok, if you need to show photographic images, such as a picture of a sunset.

For example, the following shows how an SVG image is references using the `image` Typst macro. The image is furthermore embedded in a `figure` macro. The `flex-caption` allows to include a full sentence as caption below the image and a short caption for the list of figures. Also note the use of a label `<fig:companylogo>` which is later referenced with `@fig:companylogo`:

Figure 1: The logo of the FH JOANNEUM, the University of Applied Sciences.

The application uses the logo of the company, see Figure 1, in the navigation bar to provide *home* functionality.

5.2. Backend

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Hints for code listings in Typst:

The way to include source code in your document is discussed and shown in https://typst.app/docs/reference/text/raw/. For this template we provide a custom macro/function *fhjcode* to support listings with code pulled in from external files and with line numbering. For example:

For example: We implemented a minimal *script* in Python to manage a secure `Messages` in object oriented ways. See Listing 1 and Listing 2 for a minimal `SecureMessage` class.

```
class Message:
    def __init__(self,txt):
        self.m=txt
    def __str__(self):
        return f"{self.m}"
```

Listing 1: Defining a base class in Python. Here, the base class is named *Message*.

```
class SecureMessage(Message):
    pass
```

Listing 2: For inheritance we might define a specialised class based on another class. Here, the specialised class *SecureMessage* is based on the class *Message*.

For example: As shown in Listing 2 the secure version of the class is just a stub where further improvements and extensions have to be applied.

5.3. Frontend

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Hints for abbreviations and glossary entries *gls(key)* in Typst:

Abbreviations should be written in full length on the first occurrence. Later the short version can be used. Therefore, define glossary entries with a *key* and a *short* as well as a *long* description first (see file *glossary.typ*). In the text you might use `#gls(<key>)` (and `#glspl(<key>)` for plural) usage of an abbreviation. For example:

The system is using Copy on Write (COW) for optimisation. The implementation of COW can be changed by ... Note the usage of the special configured Garbage Collection (GC). We compared many GCs to find out ..

6. | Evaluation

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Describe (proof) how your implementation really solved the stated problem. I.e. accept or reject your hypotheses. Provide a range of input data sets. Run experiments and gather the output (of tools) to meter your prototype. For the analysis, collect the measurement-data, process (e.g. filter) data and interpret the data. Include an interpretation of the work. What do the results mean to you? State current limitations of your solution. Give (personal) interpretation where suitable. Your own opinion is relevant, but must be marked clearly as such.

6.1. Setup Experiment

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For example: During the setup the GC was configured for the parallel version using the value `+UseParallelGC` for the command line argument `-XX` (`java -XX:+UseParallelGC`).

Hints on dynamically reading in external data for tables in Typst:

Using the custom macro `fhjtable` it is possible to include data dynamically for table generation. The data has to be specified in Comma-separated Values (CSV) as shown below:

Name	Profession	Experience (in years)
Max	Student	3
Mia	UX-Designer	7
Helga	Programmer	9

Table 1: Professional experience of the test users with databases.

Find in Table 1 the years a user has worked with different relational or nosql databases in a professional context.

6.2. Measurement

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Hints on using tables in Typst:

Somewhere in the normal text of the thesis the interpretation of data and information shown in a table must be discussed. Explain to the readers which numbers are important. Possibly, highlight unexpected or special data points.

	Min	**Max**	∅	σ
Network roundtrip time	34.6s	42.5s	38.1s	2.3s
Time for single request	2.4s	13.5s	**7.1s**	4.3s

Table 2: The numbers in the table above show the minimum, maximum, average ∅ , and standard deviation σ of the 273 measured network times in seconds.

For example: … Table 2 shows some calculated results on the roundtrip and request times measured in the experiment. The average, the minimum, the maximum and the standard deviations hint to a dramatic increase (> 13%) in performance in comparison to the old solution of 2003.

6.3. Interpretation of the Data

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For example: The customisation of the GC seem to have following positive and negative consequences....

Hints on dynamic calculation in Typst:

We might calculate, e.g. `#calc.max(...)`, within our document, such as max of three and seven times two is: 14.

Hints on using logic in Typst:

For example, we might use **for loop** to arrange a few images in a grid box, as shown below.

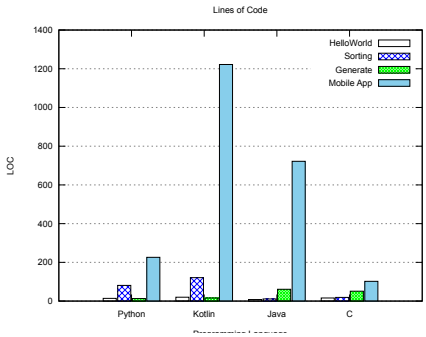

Figure 2: Compared source code by metric 1.

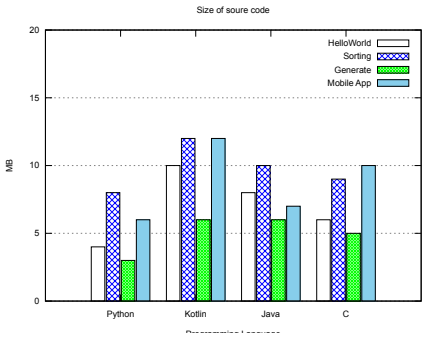

Figure 3: Compared source code by metric 2.

Hints on Charts:

Note: the charts (**vector**! images) shown have been created from raw data using the tool **gnuplot** on the command line. With `gnuplot` you can create charts by use of a textual command language. This is great for automation and it is also great for managing the source code in `git`.

7. | Conclusion and Outlook

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Sum up the results achieved and give an outlook by suggesting further research by explaining how others could built on your results.

Glossary

***COW* – Copy on Write**: Copy on Write is a memory allocation strategy where arrays are copied if they are to be modified. 7

***CSV* – Comma-separated Values** : A human readable, plain text file format using commas to separate the values. 8

***GC* – Garbage Collection**: Garbage collection is the common name for the term automatic memory management. 7, 8, 10

***SVG* – Scalable Vector Graphics**: A vector image format. 6

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