TÉCNICO LISBOA

Optimization in Architecture

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Thesis to obtain the Master of Science Degree in

Information Systems and Computer Engineering

Supervisor: Prof. António Menezes Leitão

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Acknowledgments

I would like to express my respect and gratitude to my supervisor and friend Dr. António Menezes Leitão. He proposed an interesting theme, which proved to be intriguing and challenging. His efforts to arrange research grants and to supply better computational resources were inspiring and encouraged me to fight the difficulties found along the way. His constant support, preoccupation and first-class guidance were invaluable through this thesis. Thanks for everything, especially for encouraging me to pursuit my dreams and for providing me with the flexibility and free-will to tackle this theme as something that I would be proud of.

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To each and every one of you – Thank you.

Publications

Some scientific contributions resulting from the development of this thesis are:

1. Caetano, I., Ilunga, G., **Belém, C.**, Aguiar, R., Feist, S., Bastos, F., and Leitão, A. (2018). Case Studies on the Integration of Algorithmic Design Processes in Traditional Design Workflows. Proceedings of the 23rd International Conference of the Association for CAADRIA, 1(Giedion 1941), 111–120.

2. **Belém, C.**, and Leitão, A. (2018). From Design to Optimized Design An algorithmic-based approach. Proceedings of the 36th eCAADe Conference - Volume 2, Lodz University of Technology, Poland, 549-558

Abstract

Nulla facilisi. In vel sem. Morbi id urna in diam dignissim feugiat. Proin molestie tortor eu velit. Aliquam erat volutpat. Nullam ultrices, diam tempus vulputate egestas, eros pede varius leo, sed imperdiet lectus est ornare odio. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Proin consectetuer velit in dui. Phasellus wisi purus, interdum vitae, rutrum accumsan, viverra in, velit. Sed enim risus, congue non, tristique in, commodo eu, metus. Aenean tortor mi, imperdiet id, gravida eu, posuere eu, felis. Mauris sollicitudin, turpis in hendrerit sodales, lectus ipsum pellentesque ligula, sit amet scelerisque urna nibh ut arcu. Aliquam in lacus. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Nulla placerat aliquam wisi. Mauris viverra odio. Quisque fermentum pulvinar odio. Proin posuere est vitae ligula. Etiam euismod. Cras a eros.

Keywords

Algorithmic Design; Black-Box Optimization; Machine Learning; Surrogate-based Modelling.

Resumo

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Palavras Chave

Design Algorítmico; Otimização de caixa-preta; Modelos baseados em aproximações; Aprendizagem Máquina.

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List of Algorithms

Listings

Acronyms

1

Introduction

Contents

Rui Cruz: The examples of techniques, tools, and packages along the document are for you to get familiarized with them. It is advisable to preserve those examples of usage, for reference, by moving the respective blocks of text to the last Chapter of this template (or to a Chapter file that you know you will not use), until you finish your document.

Example of using package `todo` for notes of authors. In this case the author Johnny is calling the attention for something at the specific place in the text.

Johnny: pointing out to the place

In this other case, another co-author is commenting on something inline.

Manuel: Inline comment or Note. It can be an extract of some recommended text. "Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis. Nullam sit amet enim. Suspendisse id velit vitae ligula volutpat condimentum. Aliquam erat volutpat. Sed quis velit. Nulla facilisi. Nulla libero. Vivamus pharetra posuere sapien."

In this other case, another co-author is making a note about the citation for missing some bibliographic record [1–3].

Pete: You should cite also Pellentesque:2014

Nam consectetuer. Sed aliquam, nunc eget euismod ullamcorper, lectus nunc ullamcorper orci, fermentum bibendum enim nibh eget ipsum. Donec porttitor ligula eu dolor. Maecenas vitae nulla consequat libero cursus venenatis. Nam magna enim, accumsan eu, blandit sed, blandit a, eros.

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Rui Cruz: notice here how to enquote correctly

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This is an example of Tracking ChangesXangesJO (in this case a replacement) by different authors in the document. The Text can additionally be modified by addingPT new text or by deleting wrongMN inadequate text. Author can manipulate changes introduced by each author, as adequateMNintrroduced by other authorsPT.

Proin at eros non eros adipiscing mollis. Donec semper turpis sed diam. Sed consequat ligula nec tortor. Integer eget sem. Ut vitae enim eu est vehicula gravida. Morbi ipsum ipsum, porta nec, tempor id, auctor vitae, purus. Pellentesque neque. Nulla luctus erat vitae libero. Integer nec enim. Phasellus aliquam enim et tortor. Quisque aliquet, quam elementum condimentum feugiat, tellus odio consectetuer wisi, vel nonummy sem neque in elit. Curabitur eleifend wisi iaculis ipsum.

1.1 Morbi ipsum ipsum

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RC use of ACRONYMS that are defined in file "Chapters/Thesis-MSc-Aconyms.tex

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RC the correct Name of the float object, in this case a Figure, is determined by the system

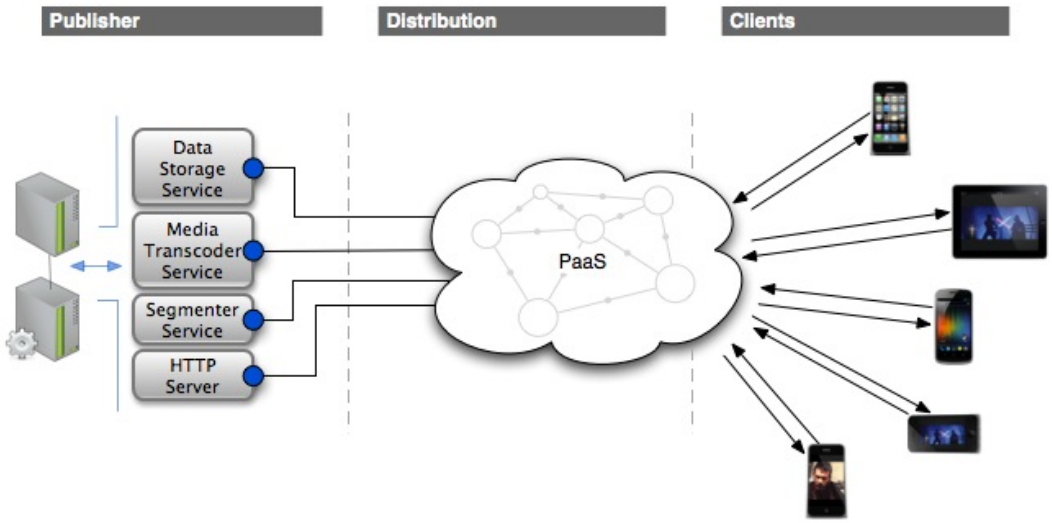

Figure 1.1: Ecosystem

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You can use in-paragraph lists with this construct for: (a) first case; (b) second case; and (c) third case, making the text organized and fluid.

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1.2 Organization of the Document

This thesis is is organized as follows: Chapter 1 interdum vel, tristique ac, condimentum non, tellus. In chapter 2 curabitur nulla purus, feugiat id, elementum in, lobortis quis, pede. In chapter 3 consequat ligula nec tortor. Integer eget sem. Ut vitae enim eu est vehicula gravida. Chapter 4 morbi egestas, urna non consequat tempus, nunc arcu mollis enim, eu aliquam erat nulla non nibh in chapter 5. Chapter 6 suspendisse dolor nisl, ultrices at, eleifend vel, consequat at, dolor.

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2

Background

Contents

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2.1 Traditional Streaming Technologies

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Sed pulvinar, “felis id consectetuer” malesuada, enim nisl mattis elit, a facilisis tortor nibh quis leo Table 2.1.

Table 2.1: Streaming Technologies Comparison

	Dynamic Streaming	Smooth Streaming	HLS
Streaming Protocol	RTMP	HTTP	HTTP
Video Codec	H.264, VP6	H.264	H.264
Audio Codec	AAC, MP3	WMA, AAC	AAC, MP3
Container Format	MP4, FLV,	MP4	MPEG2-TS
iOS	NO	YES	YES
Android	NO	YES	YES

Suspendisse vestibulum dignissim quam. Integer vel augue. Phasellus nulla purus, interdum ac, venenatis non, varius rutrum, leo. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas [8]. Duis a eros. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Fusce magna mi, porttitor quis, convallis eget, sodales ac, urna [9]. Table 2.2 illustrates the use of a Spreadsheet-like table producing calculations by columns and by lines (observe the code).

Table 2.2: A nice Spreadsheet using package “spreadtab”. Notice the calculations.

22	54	76
43	65	108
49	37	86
114	156	270

2.2 Cras lobortis tempor velit

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Table 2.3: Comparison between today's and target Architectures of Telcos

Today		Target	
Rigid	Each evolutionary requirement involves development of multiple components, interfaces, platforms,etc.	Flexible	It is possible to modify or add new functionalities rapidly.
Slow	Development of a new application takes months or years.	Fast	Development of a new application takes weeks instead of months or years.
Closed	Limited integration with external environments.	Open	It is simple to integrate internal, applications with external entities.
Complex	Heterogeneous technologies, obsolescence, lack,of standards, high redundancy.	Standardised	Use of homogeneous architectural models.
Expensive	High Capex (for new service development) and,high,Opex (to ensure running of IT).	Cost-Effective	Capex and Opex are optimised.

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3

Solution

Contents

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3.1 Architecture Design Requirements

Example of a Flowchart for a system, in Figure 3.1, created with `https://www.draw.io` and then exported as "PDF" crop format (a true vector image that can be scaled to no end, with no pixels or distortion).

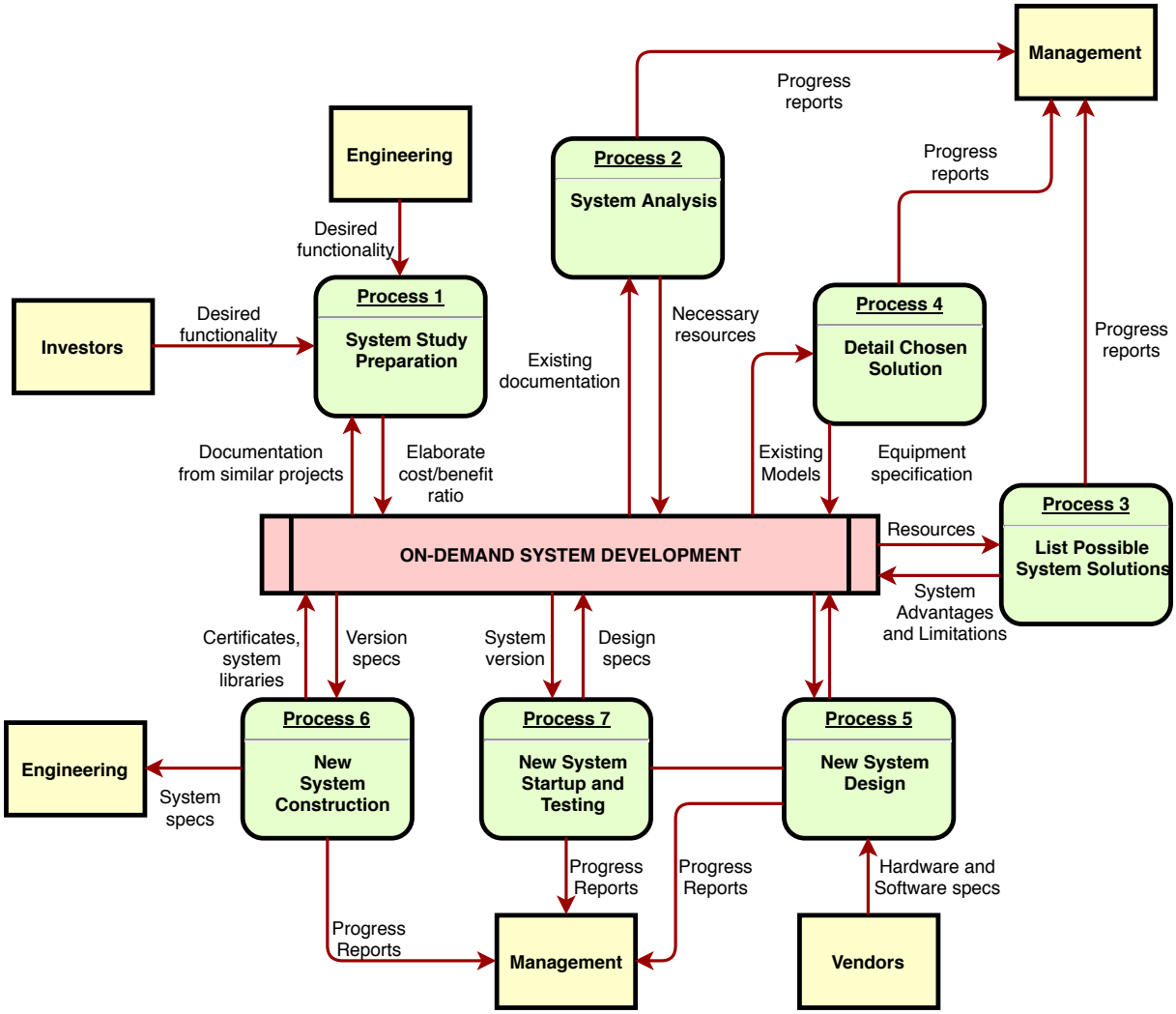

Figure 3.1: System Processes

Quisque facilisis erat a dui. Nam malesuada ornare dolor. Cras gravida, diam sit amet rhoncus

ornare, erat elit consectetuer erat, id egestas pede nibh eget odio. Proin tincidunt, velit vel porta elementum, magna diam molestie sapien, non aliquet massa pede eu diam. Aliquam iaculis. Fusce et ipsum et nulla tristique facilisis. Donec eget sem sit amet ligula viverra gravida. Etiam vehicula urna vel turpis.

And here another diagram of a network (Figure 3.2) created with `https://www.draw.io` and then exported as "PDF" crop format.

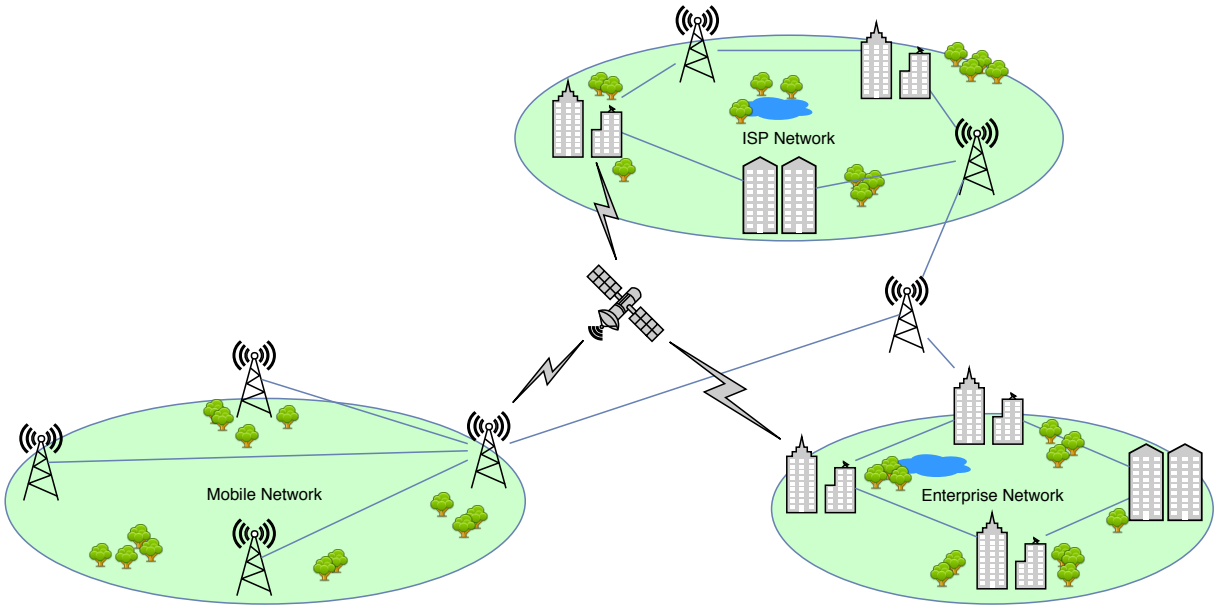

Figure 3.2: Network Diagram

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Web-streaming: The client application should support streaming media using **HTTP!** (**HTTP!**) protocols.

Multi-source streaming: The client application should support multi-source streaming media, i.e., "simultaneous" streaming of media content components from a network, supported/complemented by **CDN!** (**CDN!**)/**CC!** (**CC!**) services.

Support content Metadata Description: The client application should support content metadata description in a format similar or compliant with MPEG **DASH!** (**DASH!**) [11].

Scalable and Adaptive Media Contents: The system should support on-demand streaming of scalable and adaptive contents based on **SVC!**.

Heterogenous End-User Devices: The client application should be compatible with current and future generations of end-user devices form factors, irrespective of their performance, screen size and resolution.

Access Network independency: The solution should provide the expected service over different types of access networks supported by the end-user devices, such as Wireless **LAN!**s (**LAN!**s) (IEEE 802.11) or cellular data networks such as **GPRS!** (**GPRS!**), **UMTS!** (**UMTS!**), **LTE!** (**LTE!**), etc.

Cras gravida, diam sit amet rhoncus ornare, erat elit consectetuer erat, id egestas pede nibh eget odio. Proin tincidunt, velit vel porta elementum, magna diam molestie sapien, non aliquet massa pede eu diam. Aliquam iaculis. Fusce et ipsum et nulla tristique facilisis.

3.2 Architecture Design Requirements

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RC
A listing for XML code, with syntax highlighting

Listing 3.1: Example of a MPD file.

```
<?xml version="1.0" encoding="UTF-8"?>
<StreamInfo version="2.0">
    <Clip duration="PT01M0.00S">
        <BaseURL>videos/</BaseURL>
        <Description>svc_1</Description>
        <Representation mimeType="video/SVC" codecs="svc" frameRate="30.00" bandwidth="401.90"
            width="176" height="144" id="L0">
            <BaseURL>svc_1/</BaseURL>
            <SegmentInfo from="0" to="11" duration="PT5.00S">
                <BaseURL>svc_1-L0-</BaseURL>
            </SegmentInfo>
        </Representation>
        <Representation mimeType="video/SVC" codecs="svc" frameRate="30.00"
            bandwidth="1322.60"
            width="352" height="288" id="L1">
            <BaseURL>svc_1/</BaseURL>
            <SegmentInfo from="0" to="11" duration="PT5.00S">
                <BaseURL>svc_1-L1-</BaseURL>
            </SegmentInfo>
        </Representation>
    </Clip>
</StreamInfo>
```

Nam malesuada ornare dolor. Cras gravida, diam sit amet rhoncus ornare, erat elit consectetuer erat, id egestas pede nibh eget odio. Proin tincidunt, velit vel porta elementum, magna diam molestie sapien, non aliquet massa pede eu diam.

4

Evaluation

Contents

Aliquam aliquet, est a ullamcorper condimentum, tellus nulla fringilla elit, a iaculis nulla turpis sed wisi. Fusce volutpat. Etiam sodales ante id nunc. Proin ornare dignissim lacus. Nunc porttitor nunc a sem. Sed sollicitudin velit eu magna. Aliquam erat volutpat. Vivamus ornare est non wisi. Proin vel quam. Vivamus egestas. Nunc tempor diam vehicula mauris. Nullam sapien eros, facilisis vel, eleifend non, auctor dapibus, pede.

4.1 Development Process

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- Technology Research and Related Works
- Requirements Gathering and Study
- Design of the Architecture
- Implementation Process
- Testing and Functional Validation

Pellentesque nibh felis, eleifend id, commodo in, interdum vitae, leo. Praesent eu elit. Ut eu ligula. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Maecenas elementum augue nec nisl. Proin auctor lorem at nibh. Curabitur nulla purus, feugiat id, elementum in, lobortis quis, pede. Vivamus sodales adipiscing sapien. Vestibulum posuere nulla eget wisi. Integer volutpat ligula eget enim. Suspendisse vitae arcu. Quisque pellentesque. Nullam consequat, sem vitae rhoncus tristique, mauris nulla fermentum est, bibendum ullamcorper sapien magna et quam. Sed dapibus vehicula odio. Proin bibendum gravida nisl. Fusce lorem. Phasellus sagittis, nulla in hendrerit laoreet, libero lacus feugiat urna, eget hendrerit pede magna vitae lorem. Praesent mauris.

4.2 Development Environment

RC
Notice the reference to the Algorithm construct

Cras sed ante. Phasellus in massa. Curabitur dolor eros, gravida et, hendrerit ac, cursus non, massa. Aliquam lorem. In hac habitasse platea dictumst. Cras eu mauris Algorithm 4.1. Quisque lacus. Donec ipsum. Nullam vitae sem at nunc pharetra ultricies. Vivamus elit eros, ullamcorper a, adipiscing sit amet, porttitor ut, nibh.

Algorithm 4.1: Time Control Strategy

begin
- $nextBitrate \longleftarrow nextDownloadLevel$
- $nextBitrate \longleftarrow GetNextBitrate()$
- $cpuLoad \longleftarrow GetCpuLoad()$
- $bitrateDelta \longleftarrow getBitrateDelta(currentBitrate, nextBitrate)$
- **if** $bitrateDelta > maxThreshold$ **then**
  - $SetBitrate(nextBitrate)$
- **if** $minThreshold < bitrateDelta < maxThreshold$ **and** $numAttemps < 2$ **then**
  - $numAttemps \longleftarrow numAttemps + 1$
- **else if** $minThreshold < bitrateDelta < maxThreshold$ **and** $numAttemps = 2$ **then**
  - $numAttemps \longleftarrow 0$
- **else**
  - $SetBitrate(nextBitrate)$
- **if** $0 < bitrateDelta < minThreshold$ **and** $numAttemps < 3$ **then**
  - $numAttemps \longleftarrow numAttemps + 1$
- **else if** $0 < bitrateDelta < minThreshold$ **and** $numAttemps = 3$ **then**
  - $SetBitrate(nextBitrate)$

Maecenas adipiscing mollis massa. Nunc ut dui eget nulla venenatis aliquet. Sed luctus posuere justo. Cras vehicula varius turpis. Vivamus eros metus, tristique sit amet, molestie dignissim, malesuada et, urna..

4.3 Client Application

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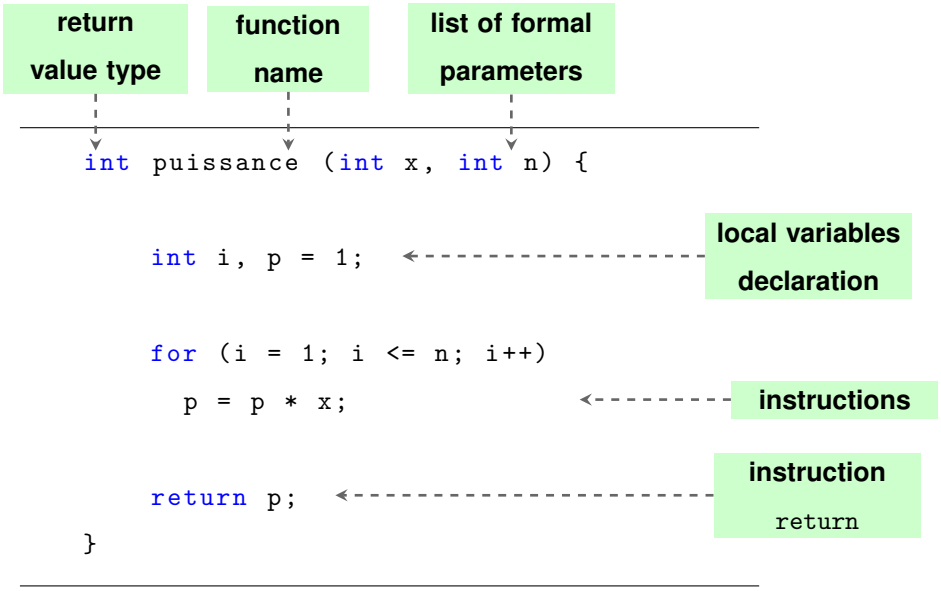

Listing 4.1: A listing with a Tikz picture overlayed

And here another method (Listing 4.1) for mixing (overlay) a picture with a listing of code.

4.3.1 User Interface

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4.3.2 Vivamus luctus elit sit amet mi

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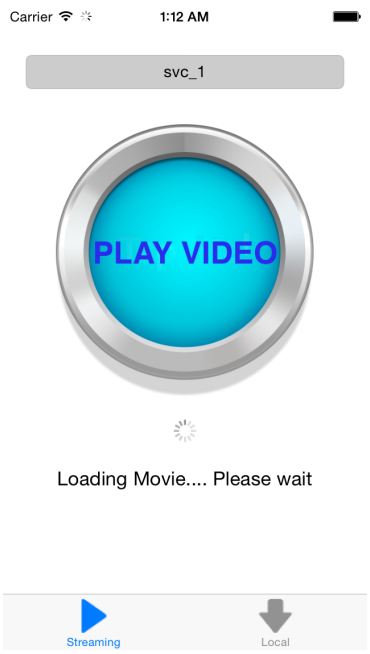
RC
A figure with Subfigures

Figures 4.1(a) and 4.1(b) proin at eros non eros adipiscing mollis.



(a) Media Loading Window

(b) Play-out Session **UI!** (**UI!**)

Figure 4.1: Complete User Interface

Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Nulla placerat aliquam wisi. Mauris viverra odio. Quisque fermentum pulvinar odio. Proin posuere est vitae ligula. Etiam euismod. Cras a eros.

5

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5.1 Maecenas vitae nulla consequat

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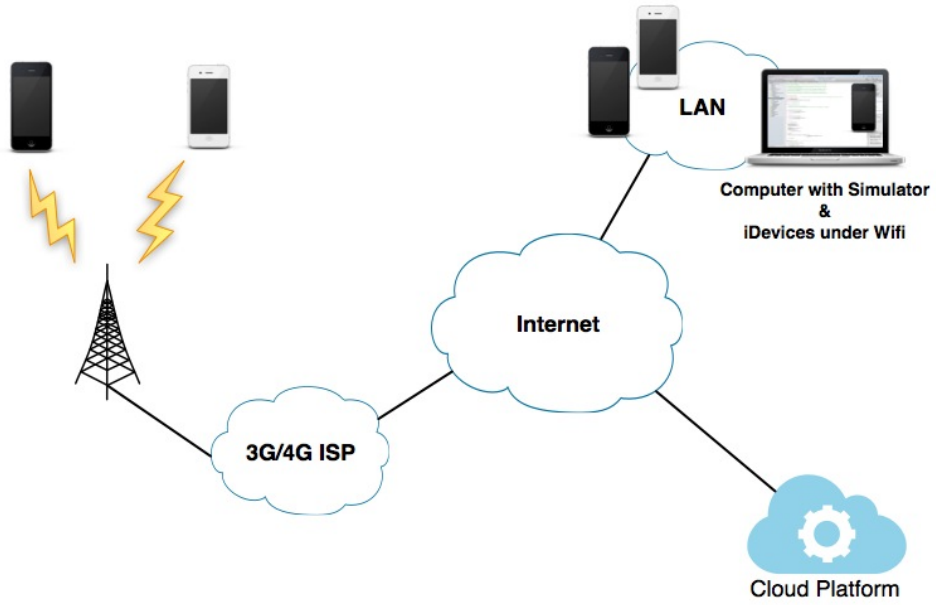

Figure 5.1: Test Environment

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Table 5.1: Network Link Conditioner Profiles

Network Profile	Bandwidth	Packets Droped	Delay
Wifi	40 mbps	0%	1 ms
3G	780 kbps	0%	100 ms
Edge	240 kbps	0%	400 ms

Aliquam aliquet, est a ullamcorper condimentum, tellus nulla fringilla elit, a iaculis nulla turpis sed wisi. Fusce volutpat. Etiam sodales ante id nunc. Proin ornare dignissim lacus. Nunc porttitor nunc a sem. Sed sollicitudin velit eu magna. Aliquam erat volutpat. Vivamus ornare est non wisi. Proin vel quam. Vivamus egestas. Nunc tempor diam vehicula mauris. Nullam sapien eros, facilisis vel, eleifend non, auctor dapibus, pede.

5.2 Proin ornare dignissim lacus

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Et “optimistic” nulla dui purus, eleifend vel, consequat non, dictum porta, nulla. Duis ante mi, laoreet ut, commodo eleifend, cursus nec, lorem. Aenean eu est. Etiam imperdiet turpis. Praesent nec augue. Curabitur ligula quam, rutrum id, tempor sed, consequat ac, dui G_j, nec ligula et lorem consequat ullamcorper p ut mauris eu mi mollis luctus j, porttitor ut, Equation (5.1), uctus posuere justo:

N_j Is the number of times peer j has been optimistically unchoked.

n_j Among the N_j unchokes, the number of times that peer j responded with unchoke or supplied segments to peer p.

$C_{r[j]}$ The cooperation ratio of peer j. If peer j never supplied peer p, the information of $C_{r[j]}$ may not be available.

$C_{r(max)}$ The maximum cooperation ratio of peer p's neighbors, i.e., $C_{r(max)} = max(C_r)$.

$$G_j = \begin{cases} \dfrac{n_j C_{r[j]}}{N_j} & \text{if } n_j > 0 \\ \dfrac{C_{r(max)}}{N_j + 1} & \text{if } n_j = 0 \end{cases} \tag{5.1}$$

Cursus $C_{r(max)}$ conubia nostra, per inceptos hymenaeos j gadipiscing mollis massa $N_j = 0$, unc ut dui eget nulla venenatis aliquet $G_j = C_{r(max)}$.

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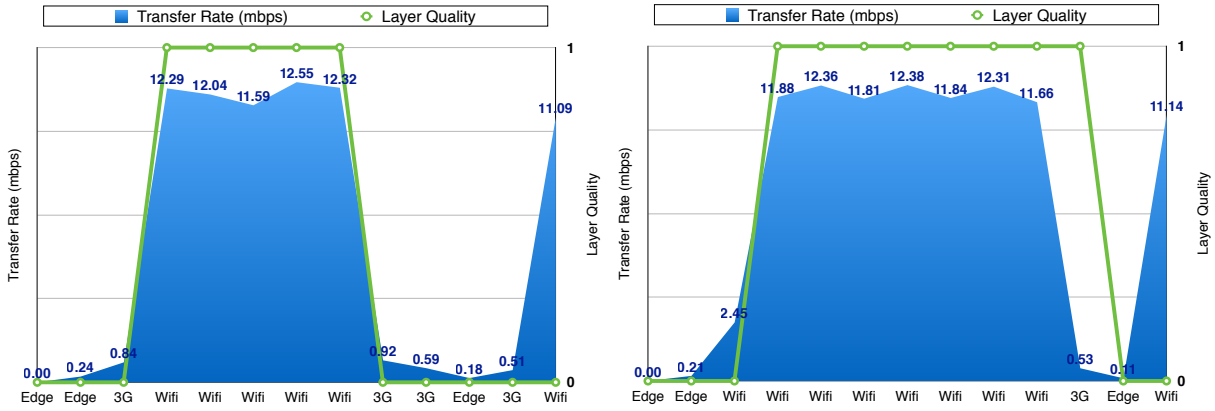

(a) Adaptation System Test 4

(b) Adaptation System Test 5

Figure 5.2: Adaptation System Behavior Test

Cras sed ante. Phasellus in massa. Curabitur dolor eros, gravida et, hendrerit ac, cursus non, massa. Aliquam lorem. In hac habitasse platea dictumst. Cras eu mauris. Quisque lacus. Donec ipsum. Nullam vitae sem at nunc pharetra ultricies. Vivamus elit eros, ullamcorper a, adipiscing sit amet, porttitor ut, nibh. Maecenas adipiscing mollis massa. Nunc ut dui eget nulla venenatis aliquet. Sed luctus posuere justo. Cras vehicula varius turpis. Vivamus eros metus, tristique sit amet, molestie dignissim, malesuada et, urna.

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Rui Cruz
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6.1 Conclusions

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6.2 System Limitations and Future Work

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