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VERIFY  
THAT THE  
MONTH IS  
JUNE



# **Multi-Objective 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 thank my parents for their friendship, encouragement and caring over all these years, for always being there for me through thick and thin and without whom this project would not be possible. I would also like to thank my grandparents, aunts, uncles and cousins for their understanding and support throughout all these years.

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I would also like to acknowledge my dissertation supervisors Prof. Some Name and Prof. Some Other Name for their insight, support and sharing of knowledge that has made this Thesis possible.

Last but not least, to all my friends and colleagues that helped me grow as a person and were always there for me during the good and bad times in my life. Thank you.

To each and every one of you – Thank you.



# Abstract

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# Keywords

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# Resumo

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## Palavras Chave

Colaborativo; Codificação; Conteúdo Multimídia; Comunicação;





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# Acronyms

<b>AVC</b>	Advanced Video Coding
<b>CC</b>	Cloud Computing
<b>CDN</b>	Content Distribution Network
<b>CPU</b>	Central Processing Unit
<b>DASH</b>	Dynamic Adaptive Streaming over HTTP
<b>GPRS</b>	General Packet Radio Service
<b>HD</b>	High Definition
<b>HTTP</b>	Hypertext Transfer Protocol
<b>LAN</b>	Local Area Network
<b>LTE</b>	Long Term Evolution
<b>OS</b>	Operating System
<b>SD</b>	Standard Definition
<b>SVC</b>	Scalable Video Coding
<b>UI</b>	User Interface
<b>UMTS</b>	Universal Mobile Telecommunication System
<b>WLAN</b>	Wireless Local Area Network
<b>WWAN</b>	Wireless Wide Area Network



# 1

## Introduction

### Contents

1.1 Morbi ipsum ipsum . . . . .	4
1.2 Organization of the Document . . . . .	5



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.

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Manuel: Inline comment or Note. It can be an extract of some recommended text. "Lorem ipsum dolor sit amet, consectetur 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."

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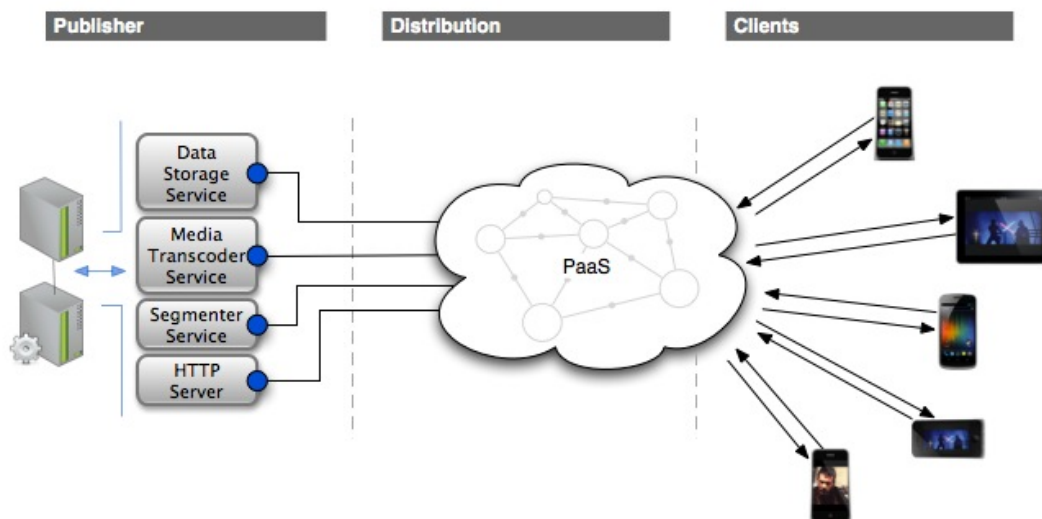
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**Figure 1.1:** Ecosystem

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## 1.2 Organization of the Document

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# 2

## This is the Second Chapter

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## 2.1 Traditional Streaming Technologies

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**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

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**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

## This is the Third Chapter

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3.2 Architecture Design Requirements . . . . .	15

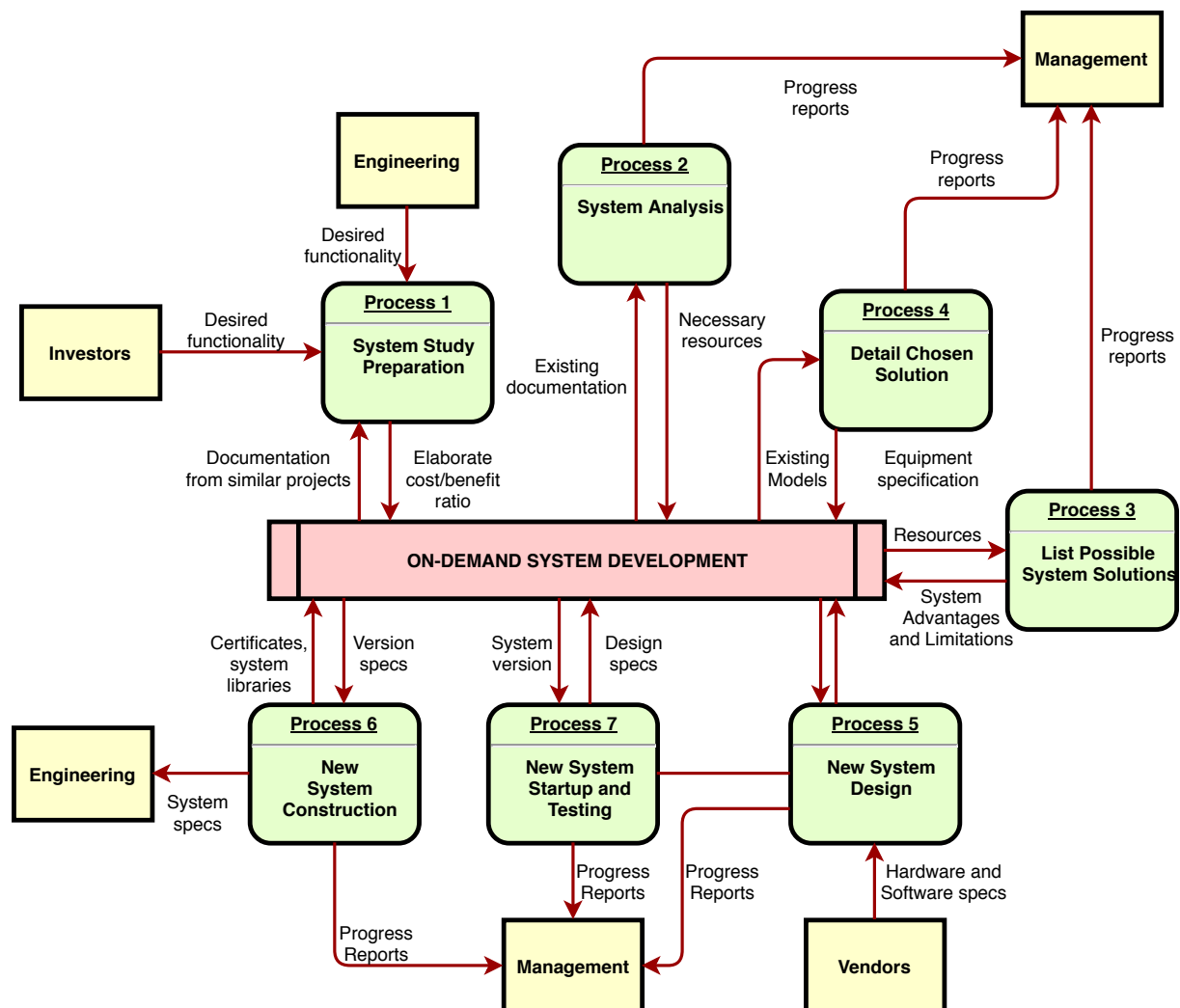
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### 3.1 Architecture Design Requirements

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).



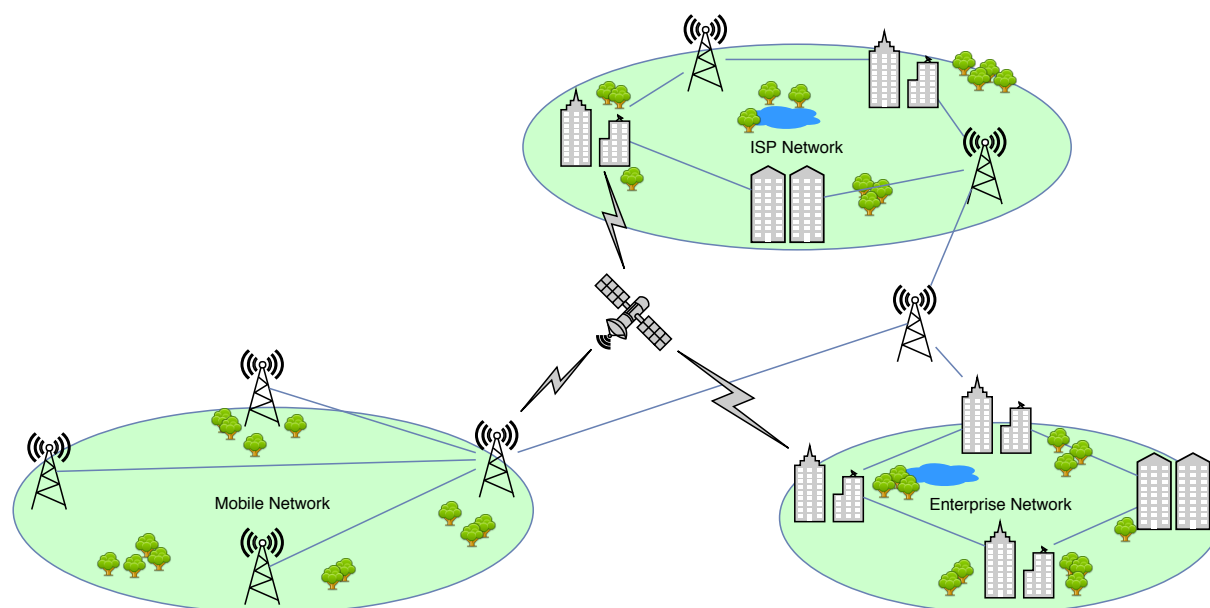
### Figure 3.1: System Processes

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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 Hypertext Transfer Protocol (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 Content Distribution Network (CDN)/Cloud Computing (CC) services.

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

**Scalable and Adaptive Media Contents:** The system should support on-demand streaming of scal-

able 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 Local Area Networks (LANs) (IEEE 802.11) or cellular data networks such as General Packet Radio Service (GPRS), Universal Mobile Telecommunication System (UMTS), Long Term Evolution (LTE), etc.

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## 3.2 Architecture Design Requirements

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**Listing 3.1:** Example of a MPD file.

```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <StreamInfo version="2.0">
3   <Clip duration="PT01M0.00S">
4     <BaseURL>videos/</BaseURL>
5     <Description>svc_1</Description>
6     <Representation mimeType="video/SVC" codecs="svc" frameRate="30.00" bandwidth="401.90"
7       width="176" height="144" id="L0">
8       <BaseURL>svc_1/</BaseURL>
9       <SegmentInfo from="0" to="11" duration="PT5.00S">
10        <BaseURL>svc_1-L0-</BaseURL>
11      </SegmentInfo>
12    </Representation>
13    <Representation mimeType="video/SVC" codecs="svc" frameRate="30.00"
14      bandwidth="1322.60"
15      width="352" height="288" id="L1">
16      <BaseURL>svc_1/</BaseURL>
17      <SegmentInfo from="0" to="11" duration="PT5.00S">
18        <BaseURL>svc_1-L1-</BaseURL>
19      </SegmentInfo>
20    </Representation>
21  </Clip>
22 </StreamInfo>
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XML code,  
with syntax  
highlighting

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# 4

## This is the Fourth Chapter

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4.3 Client Application . . . . .	20

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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

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. 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. Phasellus luctus venenatis magna. Vivamus eget lacus. Nunc tincidunt convallis tortor. Duis eros mi, dictum vel, fringilla sit amet, fermentum id, sem. Phasellus nunc enim, faucibus ut, laoreet in, consequat id, metus. Vivamus dignissim. Cras lobortis tempor velit. Phasellus nec diam ac nisl lacinia tristique. Nullam nec metus id mi dictum dignissim. Nullam quis wisi non sem lobortis condimentum. Phasellus pulvinar, nulla non aliquam eleifend, tortor wisi scelerisque felis, in sollicitudin arcu ante lacinia leo.:

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

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## 4.2 Development Environment

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reference  
to the Al-  
gorithm  
construct

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  $\leftarrow$  nextDownloadLevel
  nextBitrate  $\leftarrow$  GetNextBitrate()
  cpuLoad  $\leftarrow$  GetCpuLoad()
  bitrateDelta  $\leftarrow$  getBitrateDelta(currentBitrate, nextBitrate)

  if bitrateDelta > maxThreshold then
    | SetBitrate(nextBitrate)

  if minThreshold < bitrateDelta < maxThreshold and numAttempts < 2 then
    | numAttempts  $\leftarrow$  numAttempts + 1

  else if minThreshold < bitrateDelta < maxThreshold and numAttempts = 2 then
    | numAttempts  $\leftarrow$  0
  else
    | SetBitrate(nextBitrate)

  if 0 < bitrateDelta < minThreshold and numAttempts < 3 then
    | numAttempts  $\leftarrow$  numAttempts + 1

  else if 0 < bitrateDelta < minThreshold and numAttempts = 3 then
    | SetBitrate(nextBitrate)
```

---

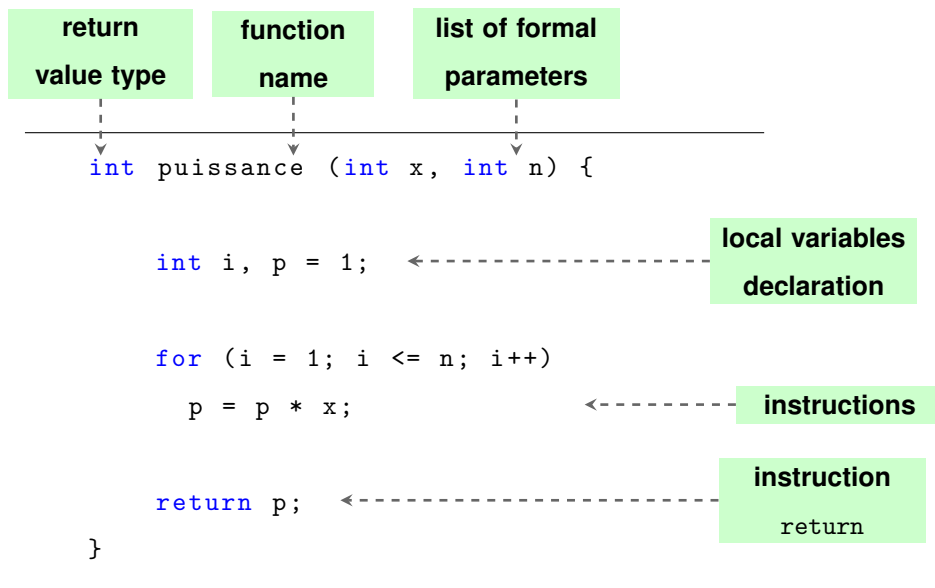
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## 4.3 Client Application

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.

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Quisque lacus. Donec ipsum. Nullam vitae sem at nunc pharetra ultricies. Cras vehicula varius turpis.



**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

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 consectetur wisi, vel nonummy sem neque in elit. Curabitur eleifend wisi iaculis ipsum. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. In non velit non ligula laoreet ultrices. Praesent ultricies facilisis nisl. Vivamus luctus elit sit amet mi. Phasellus pellentesque, erat eget elementum volutpat, dolor nisl porta neque, vitae sodales ipsum nibh in ligula. Maecenas mattis pulvinar diam. Curabitur sed leo..

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.

### 4.3.2 Vivamus luctus elit sit amet mi

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, consectetur adipiscing elit. Proin consectetur 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.

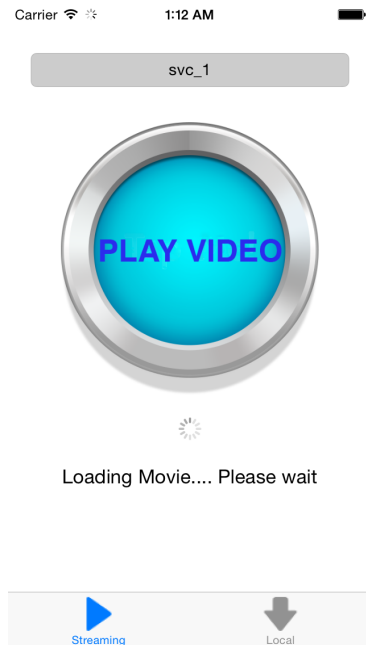
Mauris sollicitudin, turpis in hendrerit sodales, lectus ipsum pellentesque ligula, sit amet scelerisque



urna nibh ut arcu. Aliquam in lacus.

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

RC  
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with Subfig-  
ures



(a) Media Loading Window



(b) Play-out Session 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

## This is the Fifth Chapter

### Contents

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5.1	Maecenas vitae nulla consequat . . . . .	25
5.2	Proin ornare dignissim lacus . . . . .	26

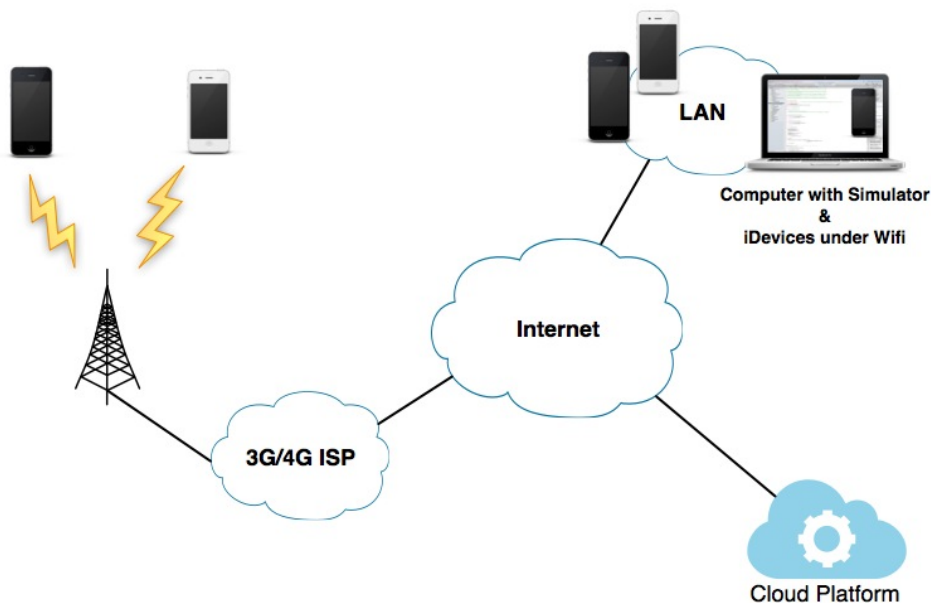
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## 5.1 Maecenas vitae nulla consequat

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**Figure 5.1:** Test Environment

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 egestas. Nunc tempor diam vehicula mauris. Nullam sapien eros, facilisis vel, eleifend non, auctor dapibus, pede Table 5.1 used in the tests. The Network Link Conditioner allows to force/simulate fluctuations in fixed network segments.

**Table 5.1:** Network Link Conditioner Profiles

Network Profile	Bandwidth	Packets Dropped	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.

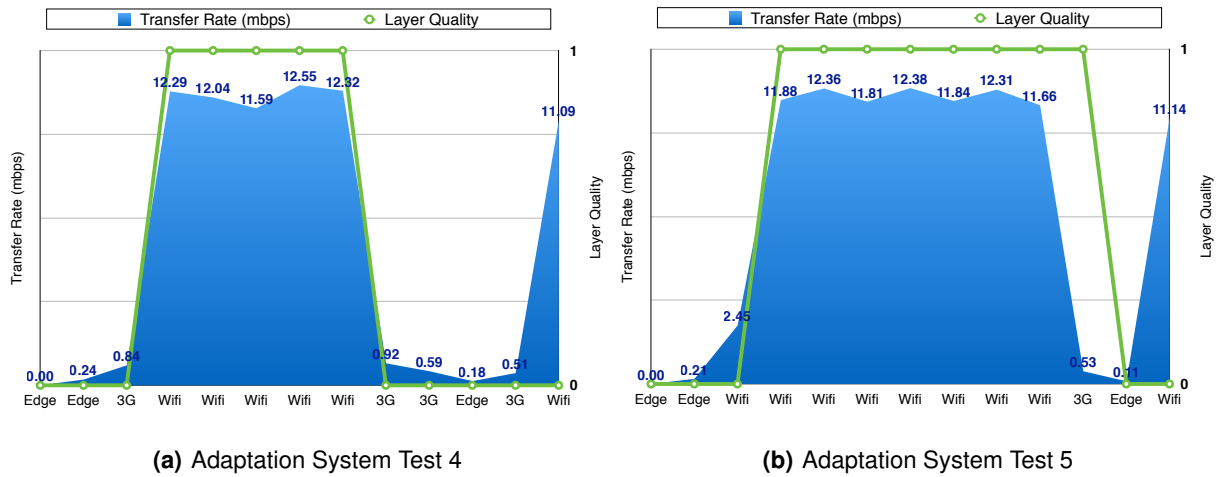
$C_{r(max)}$  The maximum cooperation ratio of peer  $p$ 's neighbors, i.e.,  $C_{r(max)} = \max(C_r)$ .

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

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

Vestibulum accumsan eros nec magna. Vestibulum vitae dui. Vestibulum nec ligula et lorem consequat ullamcorper. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Phasellus eget nisl ut elit porta ullamcorper. Maecenas tincidunt velit quis orci. Sed in dui. Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Sed cursus cursus velit. Sed a massa.

Both Figures 5.2(a) and 5.2(b) Phasellus eget nisl ut elit porta “perfect” tincidunt. Class aptent taciti sociosqu ad litora torquent per conubia nostra.



**Figure 5.2:** Adaptation System Behavior Test

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# 6

## Conclusion

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6.2	System Limitations and Future Work . . . . .	32

---





Pellentesque vel dui sed orci faucibus iaculis. Suspendisse dictum magna id purus tincidunt rutrum. Nulla congue. Vivamus sit amet lorem posuere dui vulputate ornare. Phasellus mattis sollicitudin ligula. Duis dignissim felis et urna. Integer adipiscing congue metus.

Rui Cruz  
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always  
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Chapter  
with an in-  
troductory  
text

## 6.1 Conclusions

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## **6.2 System Limitations and Future Work**

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.

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## Code of Project

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. Vestibulum accumsan eros nec magna. Vestibulum vitae dui. Vestibulum nec ligula et lorem consequat ullamcorper.

**Listing A.1:** Example of a XML file.

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

```

10         <BaseURL>svc_1-L0-</BaseURL>
11     </SegmentInfo>
12 </Representation>
13 <Representation mimeType="video/SVC" codecs="svc" frameRate="30.00" bandwidth="1322.60"
14     width="352" height="288" id="L1">
15     <BaseURL>svc_1/</BaseURL>
16     <SegmentInfo from="0" to="11" duration="PT5.00S">
17         <BaseURL>svc_1-L1-</BaseURL>
18     </SegmentInfo>
19 </Representation>
20 </Clip>
21 </StreamInfo>

```

Etiam imperdiet turpis. Praesent nec augue. Curabitur ligula quam, rutrum id, tempor sed, consequat ac, dui. Maecenas tincidunt velit quis orci. Sed in dui. Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Sed cursus cursus velit. Sed a massa. Duis dignissim euismod quam.

#### Listing A.2: Assembler Main Code.

```

1  ; *****
2  ; * Constantes
3  ; *****
4
5  ON      EQU 1 ; contagem ligada
6  OFF     EQU 0 ; contagem desligada
7  INPUT   EQU 8000H ; endereço do porto de entrada
8          ;(bit 0 = RTC; bit 1 = botão)
9  OUTPUT  EQU 8000H ; endereço do porto de saída.
10
11
12 ; *****
13 ; * Stack
14 ; *****
15
16 PLACE   1000H
17 pilha:   TABLE 100H ; espaço reservado para a pilha
18 fim_pilha:
19
20 ; *****
21
22 PLACE   2000H
23
24 ; Tabela de vectores de interrupção
25
26 tab:     WORD   rot0
27
28 ; *****
29 ; * Programa Principal
30 ; *****
31
32 PLACE   0
33
34 inicio:
35     MOV BTE, tab ; incializa BTE
36     MOV R9, INPUT ; endereço do porto de entrada
37     MOV R10, OUTPUT ; endereço do porto de saída
38     MOV SP, fim_pilha
39     MOV R5, 1 ; inicializa estado do processo P1
40     MOV R6, 1 ; inicializa estado do processo P2
41     MOV R4, OFF ; inicializa controle de RTC
42     MOV R8, 0 ; inicializa contador
43     MOV R7, OFF ; inicialmente não permite contagem
44     EIO ; permite interrupções tipo 0

```

```

45     EI                ; activa interrupções
46
47 ciclo:
48     CALL P1           ; invoca processo P1
49     CALL P2           ; invoca processo P2
50     JMP  ciclo        ; repete ciclo
51
52 ; *****
53 ;* ROTINAS
54 ; *****
55
56 P1:
57     CMP R5, 1         ; se estado = 1
58     JZ  P1_1          ; se estado = 1
59     CMP R5, 2         ; se estado = 2
60     JZ  P1_2          ; se estado = 2
61 sai_P1:
62     RET              ; sai do processo.
63
64
65 P1_1:
66     MOVB R0, [R9]     ; lê porto de entrada
67     BIT R0, 1
68     JZ  sai_P1        ; se botão não carregado, sai do processo
69     MOV R7, ON        ; permite contagem do display
70     MOV R5, 2         ; passa ao estado 2 do P1
71     JMP sai_P1
72
73 P1_2:
74     MOVB R0, [R9]     ; lê porto de entrada
75     BIT R0, 1
76     JNZ sai_P1        ; se botão continua carregado, sai do processo
77     MOV R7, OFF       ; caso contrário, desliga contagem do display
78     MOV R5, 1         ; passa ao estado 1 do P1
79     JMP sai_P1

```

Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Phasellus eget nisl ut elit porta ullamcorper. Maecenas tincidunt velit quis orci. Sed in dui. Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos.

This inline MATLAB code `for i=1:3, disp('cool'); end;` uses the `\mcode{}` command.<sup>1</sup>

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### Listing A.3: Matlab Function

```

1 for i = 1:3
2     if i >= 5 && a ~= b           % literate programming replacement
3         disp('cool');             % comment with some  $\pi x^2$ 
4     end
5     [i,ind] = max(vec);
6     x_last = x(1,end) - 1;
7     v(end);
8     ylabel('Voltage ( $\mu V$ )');
9 end

```

<sup>1</sup>MATLAB Works also in footnotes: `for i=1:3, disp('cool'); end;`



Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Sed cursus cursus velit. Sed a massa. Duis dignissim euismod quam. Nullam euismod metus ut orci.

**Listing A.4:** function.m

```
1 % Copyright 2010 The MathWorks, Inc.
2 function ObjTrack(position)
3 % #codegen
4 % First, setup the figure
5 numPts = 300;           % Process and plot 300 samples
6 figure;hold;grid;       % Prepare plot window
7 % Main loop
8 for idx = 1: numPts
9     z = position(:,idx); % Get the input data
10    y = kalmanfilter(z);  % Call Kalman filter to estimate the position
11    plot_trajectory(z,y); % Plot the results
12 end
13 hold;
14 end % of the function
```

Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Phasellus eget nisl ut elit porta ullamcorper. Maecenas tincidunt velit quis orci. Sed in dui. Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Sed cursus cursus velit. Sed a massa. Duis dignissim euismod quam. Nullam euismod metus ut orci. Vestibulum erat libero, scelerisque et, porttitor et, varius a, leo.

**Listing A.5:** HTML with CSS Code

```
1 <!DOCTYPE html>
2 <html>
3   <head>
4     <title>Listings Style Test</title>
5     <meta charset="UTF-8">
6     <style>
7       /* CSS Test */
8       * {
9         padding: 0;
10        border: 0;
```

```

11     margin: 0;
12 }
13 </style>
14 <link rel="stylesheet" href="css/style.css" />
15 </head>
16 <header> hey </header>
17 <article> this is a article </article>
18 <body>
19     <!-- Paragraphs are fine -->
20     <div id="box">
21         <p>
22             Hello World
23         </p>
24         <p>Hello World</p>
25         <p id="test">Hello World</p>
26         <p></p>
27     </div>
28     <div>Test</div>
29     <!-- HTML script is not consistent -->
30     <script src="js/benchmark.js"></script>
31     <script>
32         function createSquare(x, y) {
33             // This is a comment.
34             var square = document.createElement('div');
35             square.style.width = square.style.height = '50px';
36             square.style.backgroundColor = 'blue';
37
38             /*
39              * This is another comment.
40              */
41             square.style.position = 'absolute';
42             square.style.left = x + 'px';
43             square.style.top = y + 'px';
44
45             var body = document.getElementsByTagName('body')[0];
46             body.appendChild(square);
47         };
48

```

```

49     // Please take a look at +=
50     window.addEventListener('mousedown', function(event) {
51         // German umlaut test: Berührungspunkt ermitteln
52         var x = event.touches[0].pageX;
53         var y = event.touches[0].pageY;
54         var lookAtThis += 1;
55     });
56     </script>
57 </body>
58 </html>

```

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. Vestibulum accumsan eros nec magna. Vestibulum vitae dui. Vestibulum nec ligula et lorem consequat ullamcorper.

**Listing A.6:** HTML CSS Javascript Code

```

1
2 @media only screen and (min-width: 768px) and (max-width: 991px) {
3
4     #main {
5         width: 712px;
6         padding: 100px 28px 120px;
7     }
8
9     /* .mono {
10         font-size: 90%;
11     } */
12
13     .cssbtn a {
14         margin-top: 10px;
15         margin-bottom: 10px;
16         width: 60px;
17         height: 60px;
18         font-size: 28px;
19         line-height: 62px;
20     }

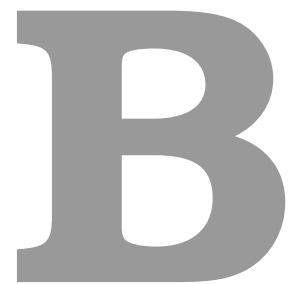
```

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**Listing A.7: PYTHON Code**

```
1 class TelegramRequestHandler(object):
2     def handle(self):
3         addr = self.client_address[0]           # Client IP-address
4         telgram = self.request.recv(1024)       # Recieve telgram
5         print "From: %s, Received: %s" % (addr, telgram)
6         return
```





## A Large Table

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**Table B.1:** Example table

Benchmark: ANN	#Layers (1)	#Nets (2)	#Nodes* (3) = 8 · (1) · (2)	Critical path (4) = 4 · (1)	Latency ( $T_{iter}$ ) (5)
A1	<b>3–1501</b>	1	<b>24–12008</b>	<b>12–6004</b>	4
A2	501	1	4008	2004	<b>2–2000</b>
A3	10	<b>2–1024</b>	<b>160–81920</b>	40	60 <sup>†</sup>
A4	10	50	4000	40	<b>80–1200</b>
Benchmark: FFT	FFT size <sup>‡</sup> (1)	#Inputs (2) = 2 <sup>(1)</sup>	#Nodes* (3) = 10 · (1) · (2)	Critical path (4) = 4 · (1)	Latency ( $T_{iter}$ ) (5)
F1	<b>1–10</b>	2–1024	<b>20–102400</b>	4–40	6–60 <sup>†</sup>
F2	<b>5</b>	32	1600	20	<b>40 – 1500</b>
Benchmark: Random networks	#Types (1)	#Nodes (2)	#Networks (3)	Critical path (4)	Latency ( $T_{iter}$ ) (5)
R1	3	10–2000	500	variable	(4)
R2	3	50	500	variable	(4) × [1; ⋯ ; 20]

\* Excluding constant nodes.

<sup>†</sup> Value kept proportional to the critical path: (5) = (4) · 1.5.

<sup>‡</sup> A size of  $x$  corresponds to a  $2^x$  point FFT.

Values in bold indicate the parameter being varied.

As Table B.1 shows, the data can be inserted from a file, in the case of a somehow complex structure. Notice the Table footnotes.

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And now an example (Table B.2) of a table that extends to more than one page. Notice the repetition of the Caption (with indication that is continued) and of the Header, as well as the continuation text at the bottom.

**Table B.2:** Example of a very long table spreading in several pages

Time (s)	Triple chosen	Other feasible triples
0	(1, 11, 13725)	(1, 12, 10980), (1, 13, 8235), (2, 2, 0), (3, 1, 0)
2745	(1, 12, 10980)	(1, 13, 8235), (2, 2, 0), (2, 3, 0), (3, 1, 0)
5490	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
8235	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
10980	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
Continued on next page		

**Table B.2 – continued from previous page**

<b>Time (s)</b>	<b>Triple chosen</b>	<b>Other feasible triples</b>
13725	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
16470	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
19215	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
21960	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
24705	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
27450	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
30195	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
32940	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
35685	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
38430	(1, 13, 10980)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
41175	(1, 12, 13725)	(1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
43920	(1, 13, 10980)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
46665	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
49410	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
52155	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
54900	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
57645	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
60390	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
63135	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
65880	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
68625	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
71370	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
74115	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
76860	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
79605	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
82350	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
85095	(1, 12, 13725)	(1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
87840	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
90585	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
93330	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
96075	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
98820	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
101565	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
104310	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
107055	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
109800	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
112545	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
115290	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
118035	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
120780	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
123525	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
126270	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
129015	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
131760	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
134505	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
137250	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
139995	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
142740	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
145485	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
148230	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)

Continued on next page



**Table B.2 – continued from previous page**

<b>Time (s)</b>	<b>Triple chosen</b>	<b>Other feasible triples</b>
150975	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
153720	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
156465	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
159210	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
161955	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
164700	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)