

**EFFICIENT MULTIRATE
TELETRAFFIC LOSS MODELS
BEYOND ERLANG**

EFFICIENT MULTIRATE
TELETRAFFIC LOSS MODELS
BEYOND ERLANG

Efficient Multirate Loss Models

Ioannis D. Moscholios
University of Peloponnese

Michael D. Logothetis
University of Patras

LOGO

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To my parents

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Contributors

MASAYKI ABE, Fujitsu Laboratories Ltd., Fujitsu Limited, Atsugi, Japan

L. A. AKERS, Center for Solid State Electronics Research, Arizona State University, Tempe, Arizona

G. H. BERNSTEIN, Department of Electrical and Computer Engineering, University of Notre Dame, Notre Dame, South Bend, Indiana; formerly of Center for Solid State Electronics Research, Arizona State University, Tempe, Arizona

Foreword

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Preface

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Acronyms

ASTA	Arrivals See Time Averages
BHCA	Busy Hour Call Attempts
BR	Bandwidth Reservation
b.u.	bandwidth unit(s)
CAC	Call / Connection Admission Control
CBP	Call Blocking Probability(-ies)
CCS	Centum Call Seconds
CDTM	Connection Dependent Threshold Model
CS	Complete Sharing
DiffServ	Differentiated Services
EMLM	Erlang Multirate Loss Model
erl	The Erlang unit of traffic-load

FIFO	First in - First out
GB	Global balance
GoS	Grade of Service
ICT	Information and Communication Technology
IntServ	Integrated Services
IP	Internet Protocol
ITU-T	International Telecommunication Union – Standardization sector
LB	Local balance
LHS	Left hand side
LIFO	Last in - First out
MMPP	Markov Modulated Poisson Process
MPLS	Multiple Protocol Labeling Switching
MRM	Multi-Retry Model
MTM	Multi-Threshold Model

PASTA	Poisson Arrivals See Time Averages
PDF	Probability Distribution Function
pdf	probability density function
PFS	Product Form Solution
QoS	Quality of Service
r.v.	random variable(s)
RED	random early detection
RHS	Right hand side
RLA	Reduced Load Approximation
SIRO	service in random order
SRM	Single-Retry Model
STM	Single-Threshold Model
TCP	Transport Control Protocol
TH	Threshold(s)
UDP	User Datagram Protocol

Introduction

The word *traffic* becomes *teletraffic* in telecommunications, as communications becomes telecommunications to indicate technology use, e.g., conversation from some distance through phones or Internet. The term teletraffic covers all kinds of computer communication traffic and telecom traffic. This book includes teletraffic loss models.

Part I

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Chapter 1

This is Chapter One Title containing authors and affiliations¹

Author I,^{1*} Author II,² Author III,¹ and Author IV³

¹*I Author Organization Division Name, Organization Name, Postal Code, Part of the Country, City Name, Street Name, Country*

²*II Author Organization Division Name, Organization Name, Postal Code, Part of the Country, City Name, Street Name, Country*

³*II Author Organization Division Name, Organization Name, Postal Code, Part of the Country, City Name, Street Name, Country*

*Corresponding Author: Author; corresauthor@gmail.com

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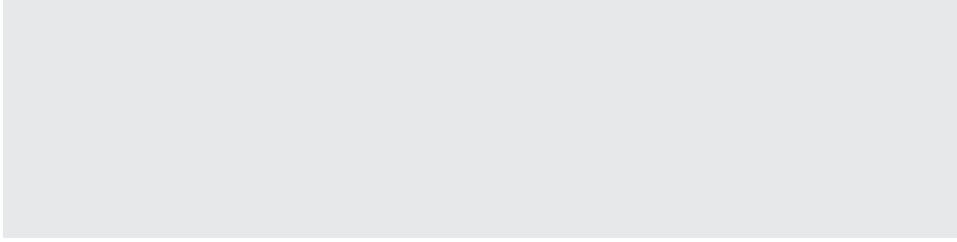


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$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^\mu D_\mu\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (1.1)$$

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^\mu D_\mu\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (1.2)$$

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3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

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² Example for a second table footnote.

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Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
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4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation 1.2).

Chapter 2

This is Chapter Two Title

After reading this chapter you should be able to:

-
- List the main subsectors and components of the environmental and energy infrastructure
 - Explain www.google.com the function of each infrastructure sector
 - Identify components related to environmental and energy infrastructure
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The manifestation of solar activity¹ (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

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An example for uppercase alphabet list:

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- B. Item text Item text Item text Item text Item text Item text Item text Item text. Item text Item text.

An example for lowercase alphabet list:

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- b. Item text Item text Item text Item text Item text Item text Item text Item text. Item text Item text.
- c. Item text Item text Item text Item text Item text Item text Item text Item text. Item text Item text.

Eample for uppercase Roman List:

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- II. Item text Item text Item text Item text Item text Item text Item text. Item text Item text.
- III. Item text Item text Item text Item text Item text Item text

Eample for lowercase roman List:

- i. Lower case roman list text. Item text Item text Item text Item text Item text Item text Item text.
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- iii. Item text Item text Item text Item text Item text Item text

Example for custom list:

- Step 1 Custom list, if the list environment not matched with above.
- Step 2 Item text Item text Item text Item text Item text Item text Item text. Item text Item text Item text. Item text Item text.
- Step 3 Item text Item text Item text Item text Item text Item text

Example for unnumbered list:

- Unnumbered list text. Item text Item text Item text Item text Item text Item text Item text. Item text.
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Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
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4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

Source: Example for table source text.

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4	–10.0	12,900 ²	–10.0
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hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Refer Figure 2.1 and Table 2.2 for more details.

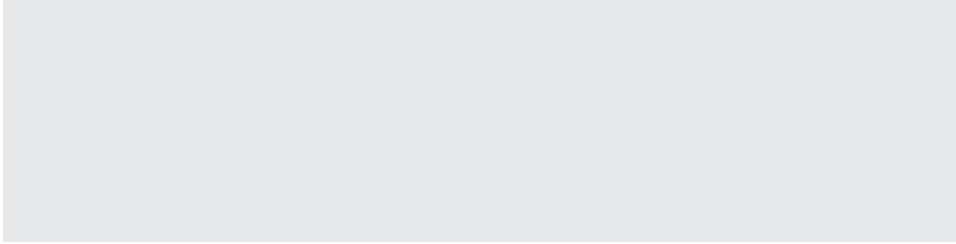


Figure 2.1: Figure Title.

Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption.
Figure Caption. Figure Caption.

Source: Figure Source.

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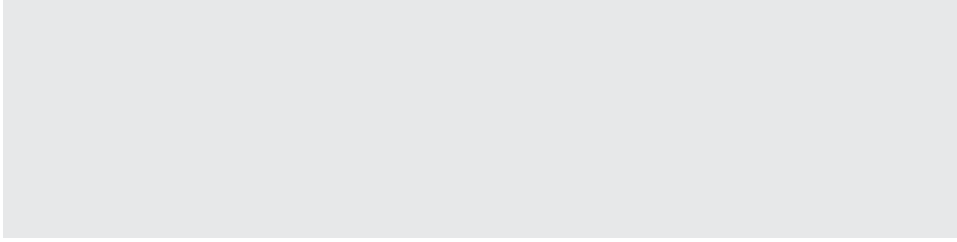


Figure 2.2: Figure Caption. Figure Caption. Figure Caption. Figure Caption.
Figure Caption. Figure Caption. Figure Caption.

commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

The manifestation of solar activity² (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation 2.1).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^\mu D_\mu\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (2.1)$$

The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers(Equation 2.2).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^\mu D_\mu\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (2.2)$$

²This is an example for second text footnote. This is an example for second text footnote.
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Part II

This is an example for part two title

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Chapter 3

This is Chapter Three Title

After reading this chapter you should be able to:

-
- List the main subsectors and components of the environmental and energy infrastructure
 - Explain www.google.com the function of each infrastructure sector
 - Identify components related to environmental and energy infrastructure
-

3.1. This is First Level Heading

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The manifestation of solar activity¹ (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

Example for Quotes

Quote Head

Quote Text Quote Text Quote Text Quote Text Quote Text Quote
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Quote Text

Quote Source

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Quote Source

¹This is an example for first text footnote. This is an example for first text footnote. This is an example for first text footnote.

Example for Extracts

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Extract Source

*Extract Text Extract Text Extract Text Extract Text Extract
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*‘Extract Text Extract Text Extract Text Extract Text Extract
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Extract Source

Example for Pull quotes

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Quote Text Quote Text Quote Text Quote Text Quote Text Quote Text

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Example for Verse/Poetry

Poetry Title

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here

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Verse Text here Verse Text here Verse Text here Verse Text here

Source: Verse/Poetry Source

Example for Epigraph

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graph Text Epigraph Text Epigraph Text Epigraph Text Epigraph Text
Epigraph Text*

Epigraph Source

Example for Dialogue

Speaker A: Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Di-
alogue Text. Dialogue Text. Dialogue Text. Dialogue Text.

Speaker B: Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text.

Speaker A: Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text. Dialogue Text.

The manifestation of solar activity² (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

Exercises

1. Item 1 What is the meaning of life?

Ans: b

- a. for italic text
- b. for bold text
- c. for small caps
- d. for text with

2. Item 2 What is the meaning of life?

Hint: Answering this requires Deep Thought.

Ans: 42

See THHGTTG.

3. Item 3 What is the meaning of life?

Another type of layout for exercises:

²This is an example for first text footnote. This is an example for first text footnote. This is an example for first text footnote.

Chapter 4

This is Chapter Four Title

After reading this chapter you should be able to:

-
- List the main subsectors and components of the environmental and energy infrastructure
 - Explain www.google.com the function of each infrastructure sector
 - Identify components related to environmental and energy infrastructure
-

4.1. This is First Level Heading

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The manifestation of solar activity¹ (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

Example for Feature Fixed

TIP Feature Head

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¹This is an example for first text footnote. This is an example for first text footnote. This is an example for first text footnote.

FEATURE FIXED HEAD

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Text.

Example for Boxes

Feature Title 4.3

Feature Section

Feature Subsection

Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession.

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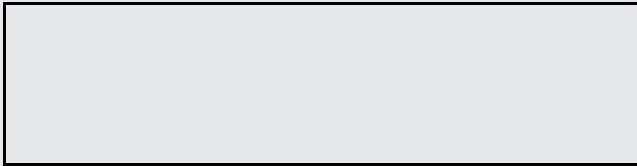


Figure 4.1: Figure Title. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. *Source: Figure Source.*

Note: For sample purpose we have used dummy eps image. Please use only the below format:

```
\begin{figure}
\includegraphics{FigName.eps}
\caption{\title{Figure Title.}Figure Caption.
Figure Caption. Figure Caption. Figure Caption.
Figure Caption. Figure Caption. Figure Caption.
\source{\textit{Source:} Figure Source.}\label{fig1}}
\end{figure}
```

Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession.

Table 4.1: Enter table caption here.

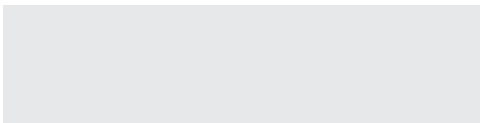
Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

Source: Example for table source text.

¹ Example for a first table footnote. Example for a first table footnote. Example for a first table footnote. Example for a first table footnote.

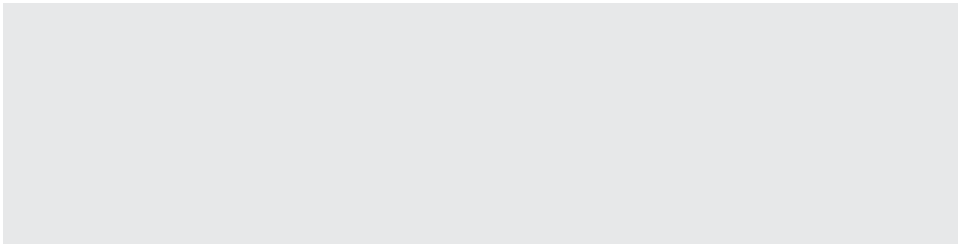
² Example for a second table footnote.

The sample for unnumbered Figure with caption



Unnumbered Figure Title. Unnumbered Figure caption. Unnumbered Figure caption. Unnumbered Figure caption. Unnumbered Figure caption. *Unnumbered Figure Source*

The sample for unnumbered Figure without caption



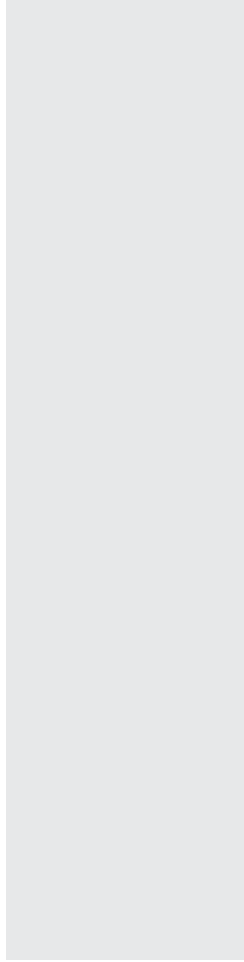


Figure 4.2: Figure Title

Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption.

Source: Figure Source.

This is an unnumbered table

Enter unnumbered table caption here. Enter
unnumbered table caption here. Enter unnumbered
table caption here.

Tap	Relative	Relative	Relative mean
number	power (dB)	delay (ns)	power (dB)
3	0–9.0	68,900	–12.8
4	–10.0	12,900	–10.0
5	–15.0	17,100	–25.2
6	–20.0	20,000 ¹	–16.0

¹ This is unnumbered table footnote
Source: This is unnumbered table source. This is un-
numbered table footnote

Table 4.2: Enter sideways table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900	–12.8
4	–10.0	12,900	–10.0
5	–15.0	17,100 ¹	–25.2

¹ This is table footnote

For Unnumbered Table without caption and source/note:

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900	–12.8
4	–10.0	12,900	–10.0
5	–15.0	17,100	–25.2
6	–20.0	20,000	–16.0

Chapter 5

This is Chapter Five Title

After reading this chapter you should be able to:

-
- List the main subsectors and components of the environmental and energy infrastructure
 - Explain www.google.com the function of each infrastructure sector
 - Identify components related to environmental and energy infrastructure
-

5.1. This is First Level Heading

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The manifestation of solar activity¹ (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

Enunciations

For bold head and italic body:

Theorem 5.1(*Theorem Title*): *Theorem content. Theorem content. Theorem content. Theorem content. Theorem content. Theorem content.*

Lemma 5.1: *Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content.*

¹This is an example for first text footnote. This is an example for first text footnote. This is an example for first text footnote.

Corollary 5.1: *Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content.*

For bold head and roman text:

Definition 5.1(*Definition Title*): Definition content. Definition content. Definition content. Definition content. Definition content. Definition content. Definition content.

Remark 5.1: Remark content.

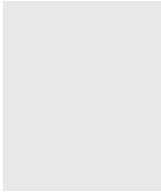
For proofs:

Proof. Proof content. Proof content. Proof content. Proof content. Proof content. Proof content. Proof content. Proof content. Proof content. Proof content. Proof content. Proof content. Proof content. Proof content.

Computer Material

```
class CEcosystem;
struct Chromosome
{
    unsigned char gene[CHROMOLENGTH];
};
```

Icons



Icon text. Icon text. Icon text. Icon text. Icon text. Icon text.

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Following is an example for Problems section:

Problems

Related Instruction. Related Instruction. Related Instruction. Related Instruction. Related Instruction.

1. First problem text. First problem text. First problem text.

$$f(x) = \begin{cases} kx^2(1 - x^3), & 0 \leq x \leq 1 \\ 0, & \text{otherwise} \end{cases}$$

continuation of first problem text.

Hint: Problem hint text. Problem hint text.

2. Second problem text. Second problem text. Second problem text:

1. $9 < X < 90$.
2. $X < 90$.
3. $X > 90$, given that $X > 9$.

3. Third problem text. Third problem text.

$$F_X(x) = \begin{cases} 0, & x < 0, \\ \frac{1}{2}\sqrt{x} + \frac{1}{2}(1 - e^{-\sqrt{x}}), & 0 \leq x \leq 1, \\ \frac{1}{2} + \frac{1}{2}(1 - e^{-\sqrt{x}}), & x > 1. \end{cases}$$

Continuation of third problem text.

4. Fourth problem text.

$$f_X(x) = \frac{k}{x}, \quad k > 0.$$

Continuation of fourth problem text

1. some text.
2. some other text.
3. more text.

Appendix A

This is Appendix Title

A.1. This is First Level Heading

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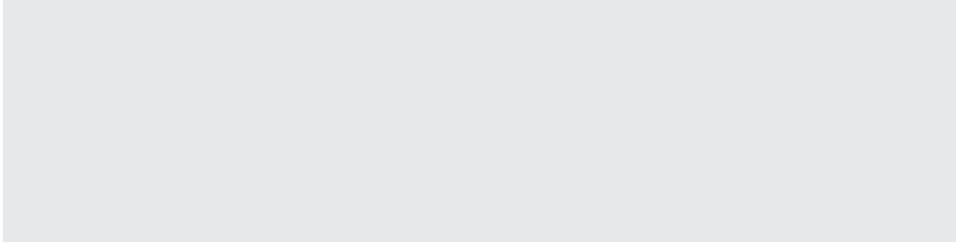


Figure A.1: Figure Title

Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption.
Figure Caption. Figure Caption.

Source: Figure Source.

penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam
tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus
mauris.

A.1.1. This is Second Level Heading

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pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa
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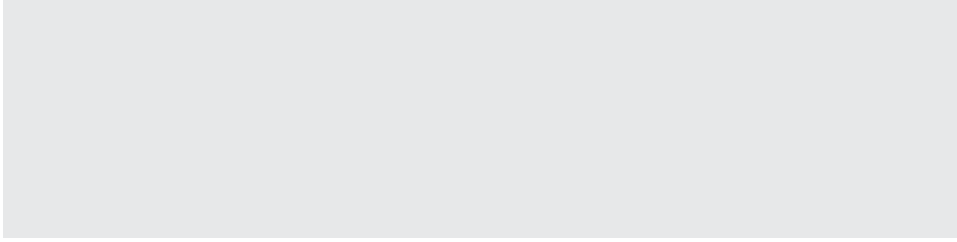


Figure A.2: Figure Title

Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption.
Figure Caption. Figure Caption.

Source: Figure Source.

A.1.1.1. This is Third Level Heading

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation A.1, Table A.1 and Figure A.1).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^\mu D_\mu\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (\text{A.1})$$

Table A.1: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation A.2, Table A.2 and Figure A.2).

$$\mathcal{L} = i\bar{\psi}\gamma^{\mu}D_{\mu}\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (\text{A.2})$$

Table A.2: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

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Appendix B

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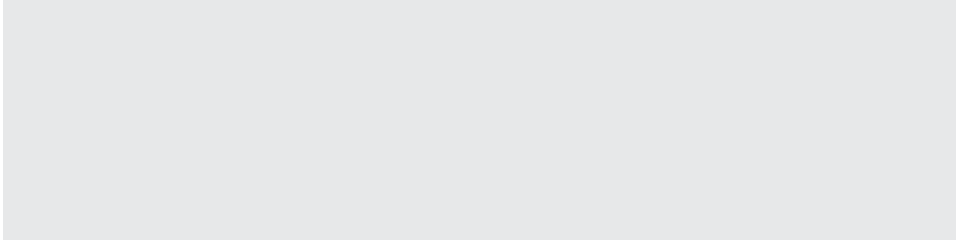


Figure B.1: Figure Title.

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The manifestation of solar activity (flares, bursts, and others) occurs over

Table B.1: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
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The manifestation of solar activity (flares, bursts, and others) occurs over

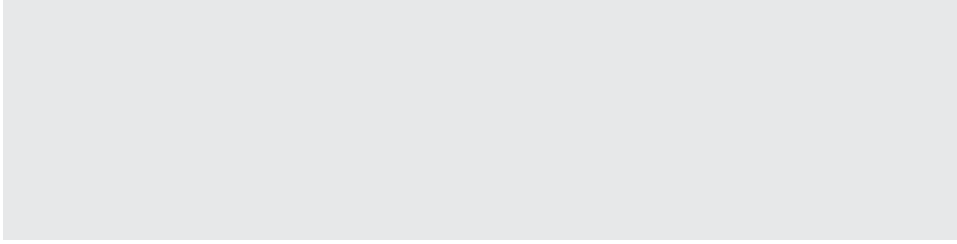


Figure B.2: Figure Title.

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Table B.2: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
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the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation B.2, Table B.2 and Figure B.2).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^\mu D_\mu\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (\text{B.2})$$

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