EFFICIENT MULTIRATE

TELETRAFFIC LOSS MODELS

BEYOND ERLANG

EFFICIENT MULTIRATE TELETRAFFIC LOSS MODELS BEYOND ERLANG

Efficient Multirate Loss Models

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LOGO

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To my parents

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Foreword

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Preface

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I. R. S.

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 Unit – 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.

Chapter 1

This is Chapter One Title containing authors and affiliations[1]

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

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[8], citep: [5, 8]. As you see in Table 1.1, the citations are to their reference in the bibliography (Equation 1.1).

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

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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.

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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

2.1. This is First Level Heading

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The manifestation of solar activity[1] (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 lowercase alphabet list:

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Refer Figure 2.1 and Table 2.2 for more details.

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The manifestation of solar activity[2] (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).

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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

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

Chapter 3

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- Identify components related to environmental and energy infrastructure

3.1. This is First Level Heading

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The manifestation of solar activity[1] (flares, bursts, and others) occurs over the whole Sun,

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

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

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Example for Extracts

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Example for Pull quotes

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Example for Verse/Poetry

Poetry Title

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Source: Verse/Poetry Source

Example for Epigraph

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>
> *Epigraph Source*

Example for Dialogue

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

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

The manifestation of solar activity[2] (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

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

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:

Exercise 3.1: Exercise content.

Solution: Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text.

Exercise 3.2: Exercise content.

Solution: Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution Text. Solution

Text.

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 activity[1] (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

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FEATURE FIXED HEAD

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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.

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- Bulleted list text. Item text Item text Item text Item text Item text Item text Item text.
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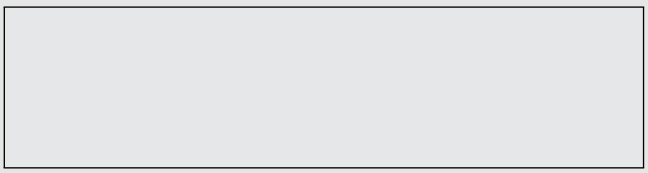

Figure 4.1: Figure Title. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure

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.

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. 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 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[1]	−16.0

[1] This is unnumbered table footnote

Source: This is unnumbered table source. This is unnumbered 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 activity[1] (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.*

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

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. Definition content. Definition content.

Remark 5.1: Remark content.

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

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. Proof content.

Computer Material

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

Icons

Icon text. Icon text.

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.

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

   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.

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

Continuation of third problem text.

4. Fourth problem text.

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

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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A.1.1. This is Second Level Heading

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Figure A.1: Figure Title

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Source: Figure Source.

libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

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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

Figure A.2: Figure Title

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Source: Figure Source.

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

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.

terrestrial observers (Equation A.1, Table A.1 and Figure A.1).

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

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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

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.

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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).

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

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Appendix B

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B.1.1. This is Second Level Heading

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Figure B.1: Figure Title.

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Source: Figure Source.

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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 B.1, Table B.1 and Figure B.1).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^{\mu}D_{\mu}\psi - \frac{1}{4}F^{a}_{\mu\nu}F^{a\mu\nu} - m\bar{\psi}\psi \tag{B.1}$$

B.1.1.1. This is Third Level Heading

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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
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.

Figure B.2: Figure Title.

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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 B.2, Table B.2 and Figure B.2).

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

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
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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Appendix C

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C.1. Import Codes From Code File

```
#%%
import numpy as np
import scipy.stats as st

import matplotlib.pyplot as plt
import seaborn as sns

sns.set_palette("Paired")
```

C.2. Write Codes In Tex File

```
import numpy as np

def incmatrix(genl1,genl2):
    m = len(genl1)
    n = len(genl2)
    M = None #to become the incidence matrix
    VT = np.zeros((n*m,1), int)  #dummy variable

    #compute the bitwise xor matrix
    M1 = bitxormatrix(genl1)
    M2 = np.triu(bitxormatrix(genl2),1)

    for i in range(m-1):
        for j in range(i+1, m):
            [r,c] = np.where(M2 == M1[i,j])
            for k in range(len(r)):
                VT[(i)*n + r[k]] = 1;
                VT[(i)*n + c[k]] = 1;
                VT[(j)*n + r[k]] = 1;
                VT[(j)*n + c[k]] = 1;
```

```
21
24                  if M is None:
25                      M = np.copy(VT)
26                  else:
27                      M = np.concatenate((M, VT), 1)
28
29                  VT = np.zeros((n*m,1), int)
30
31      return M
```

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