School of Engineering Technology and Applied Science

S2P: SUSTAINABLE SERVICE PRICING IN CLOUD ECOSYSTEMS

Reza Dibaj

Outline

- Introduction
- Main pricing model challenges
- Influential Factors on Cloud Pricing
- An Elephant in the Light: A Comprehensive Pricing Factors Taxonomy
- Contribution One: Sustainable Fair Pricing Mechanism
  - Related Work for Contribution One
  - My Methodology for Contribution One
- Contribution Two: Dynamic Resource Allocation (DRA)
  - Introduction to Contribution Two
  - My Methodology for Contribution Two
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Introduction

National Institute of Standards and Technology (**NIST**): "**cloud computing** is a model for enabling **ubiquitous**, **convenient**, **on-demand network access** to a shared pool of **configurable computing resources** (e.g. networks, servers, storage, applications, and services) that can be **rapidly provisioned** and **released with minimal management effort** or **service provider interaction**."
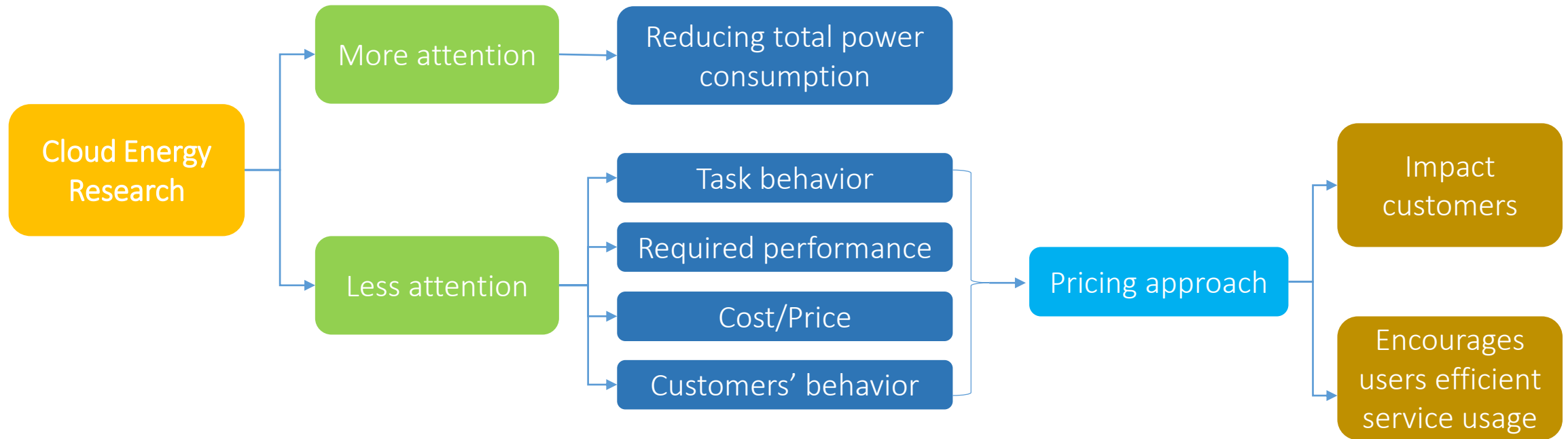
Introduction

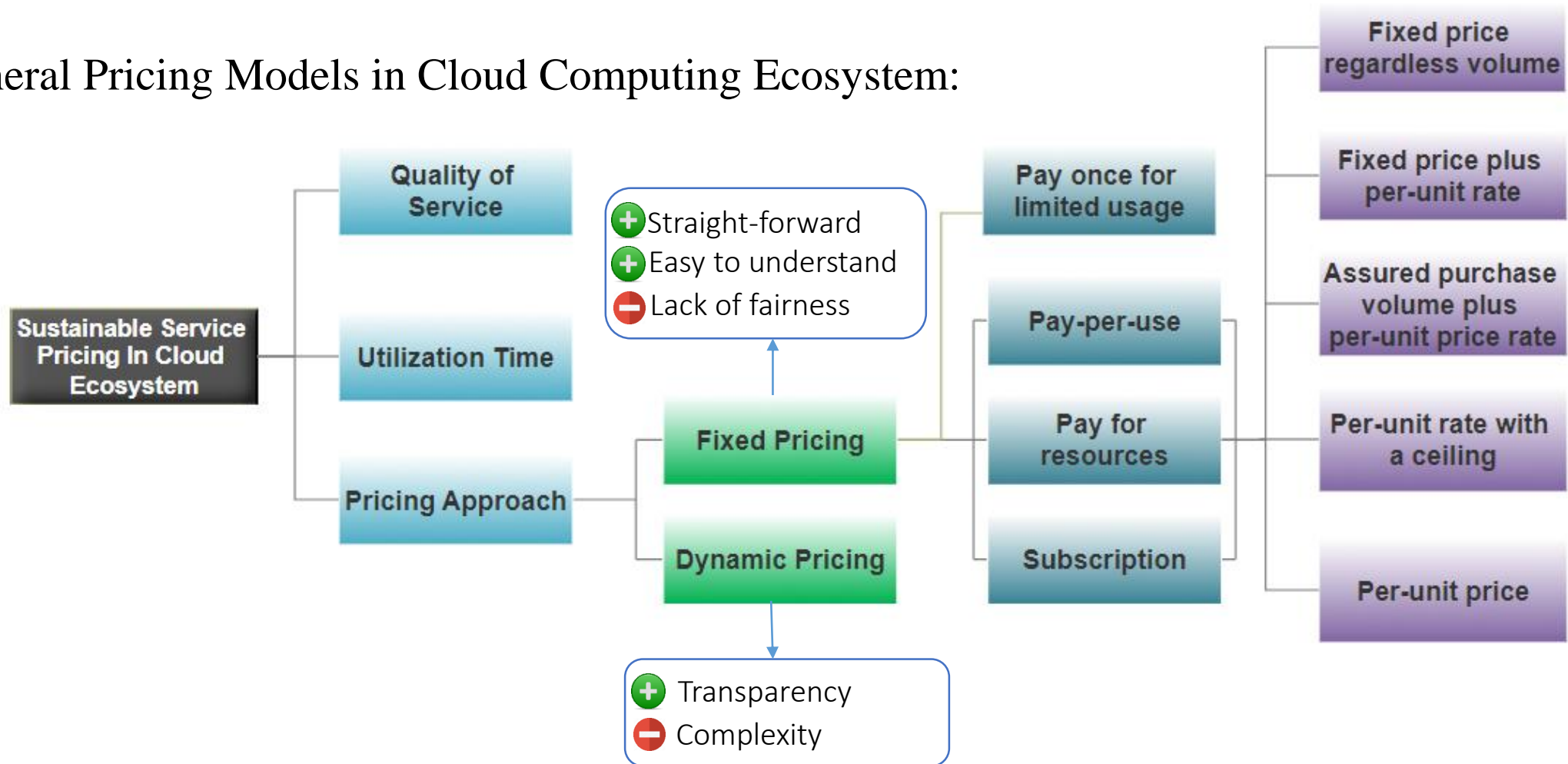Energy efficient and management techniques:
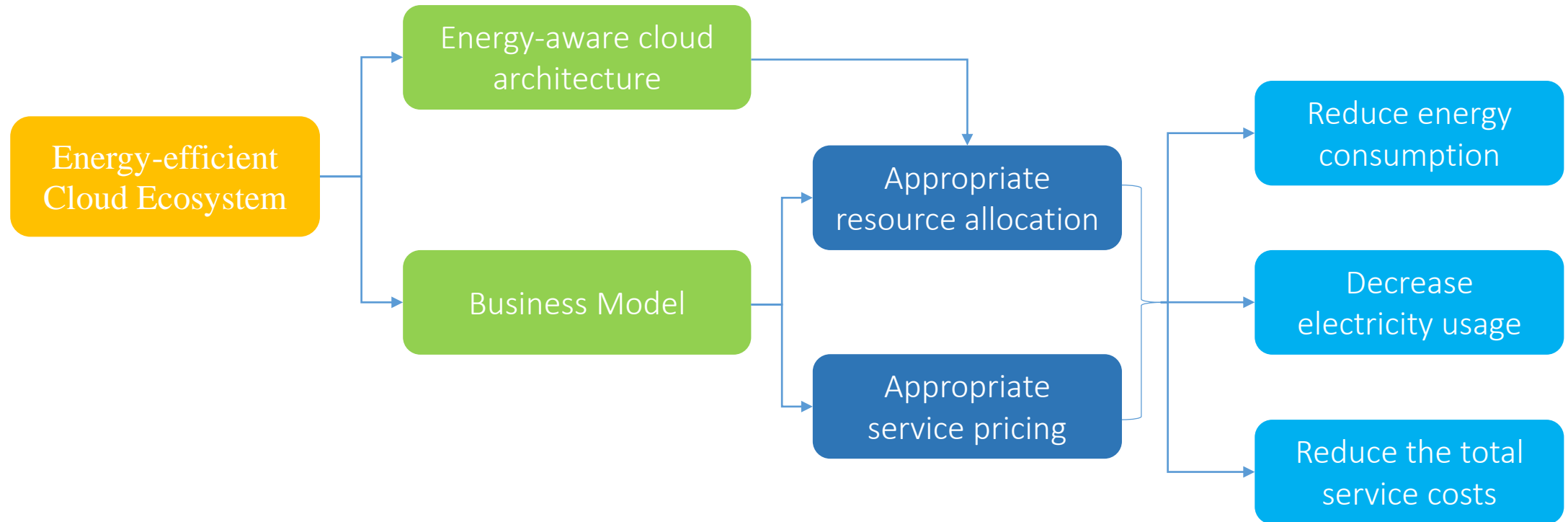
Introduction

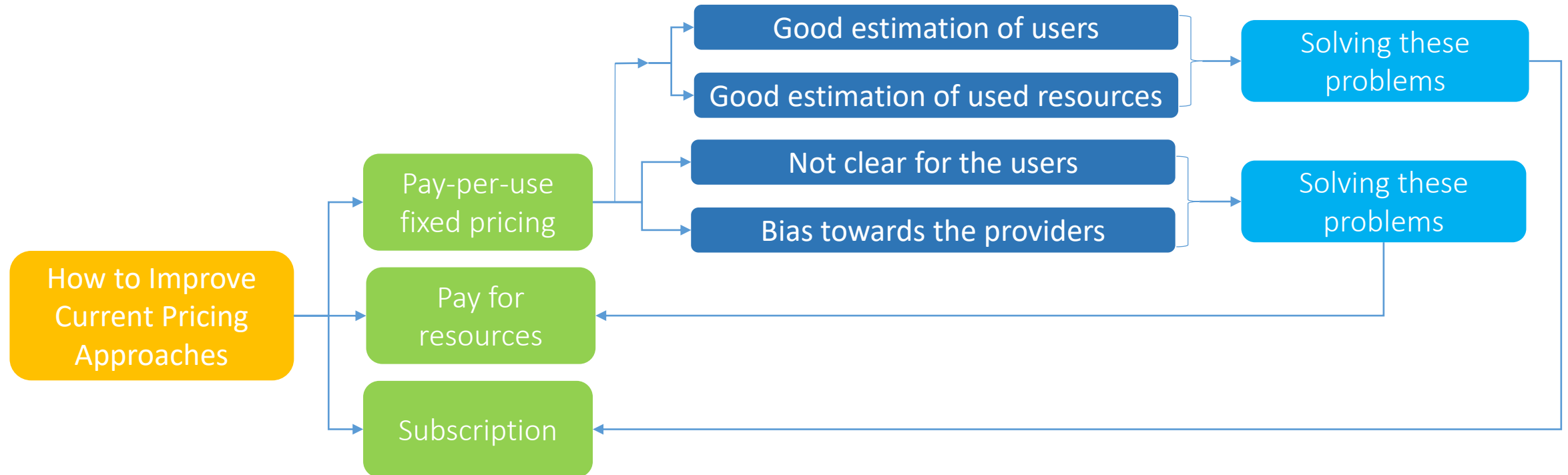Energy efficient and management techniques:

Introduction

General Pricing Models in Cloud Computing Ecosystem:

Introduction

How to Improve Current Pricing Approaches:

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Main pricing model challenges

Describing the main pricing model challenges [31]:
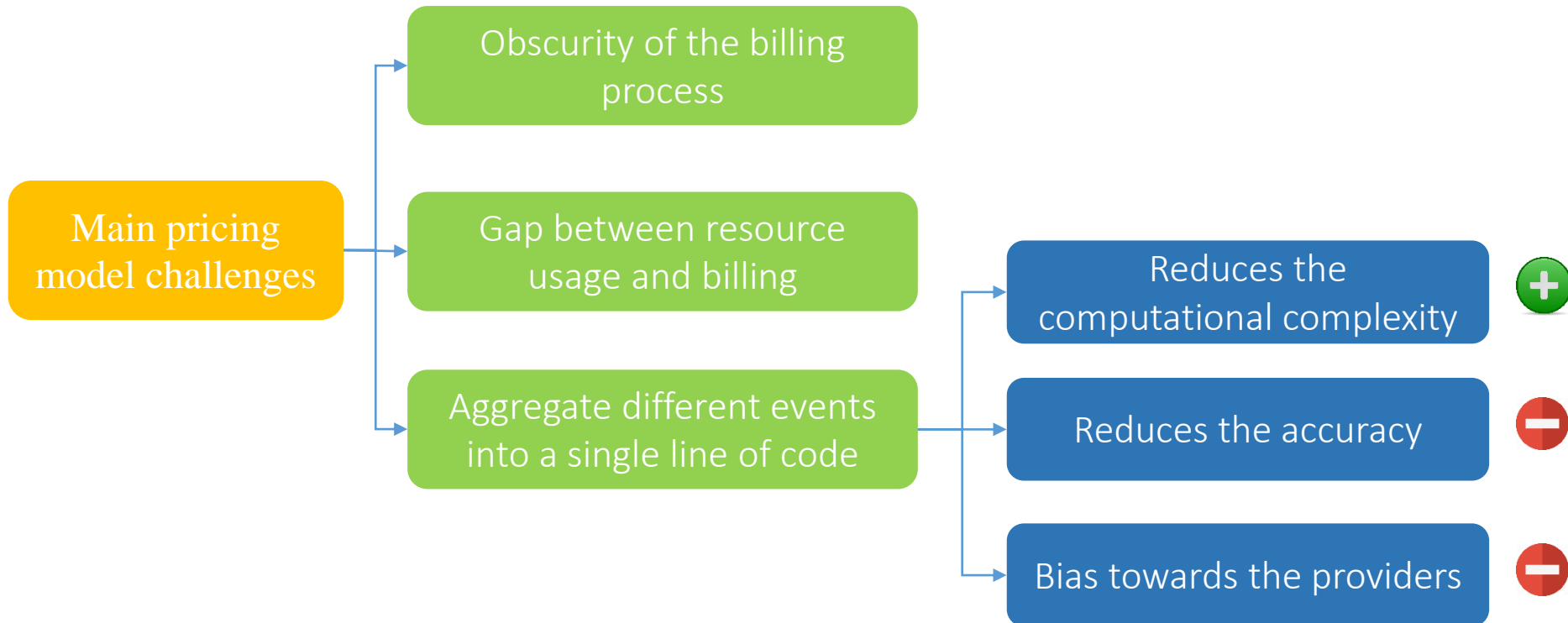
Outline

Influential Factors on Cloud Pricing

Defining influential factors on cloud pricing [32]:
- Initial costs
- Lease period
- Quality of Service
- Age of resources
- Cost of maintenance

👎 Which items are static and which items are dynamic?

👎 How should we treat static and dynamic factors in cloud service calculations?

👎 How about other important factors, such as greenness of the energy resources, electricity costs, fairness, competition, market demands and et cetera.

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An Elephant in the Dark

Some Hindus have an elephant to show.
No one here has ever seen an elephant.
They bring it at night to a dark room.
One by one, we go in the dark and come out
Saying how we experience the animal.
One of us happens to touch the trunk.
A water-pipe kind of creature.
Another, the ear. A very strong, always moving
Back and forth, fan-animal. Another, the leg.
I find it still, like a column on a temple.
Another touches the curved back.
A leathery throne. Another the cleverest,
Feels the tusk. A rounded sword made of porcelain.
He is proud of his description.
Each of us touches one place
And understands the whole that way.
The palm and the fingers feeling in the dark
Are how the senses explore the reality of the elephant.
If each of us held a candle there,
And if we went in together, we could see it.
-Rumi

An Elephant in the Light
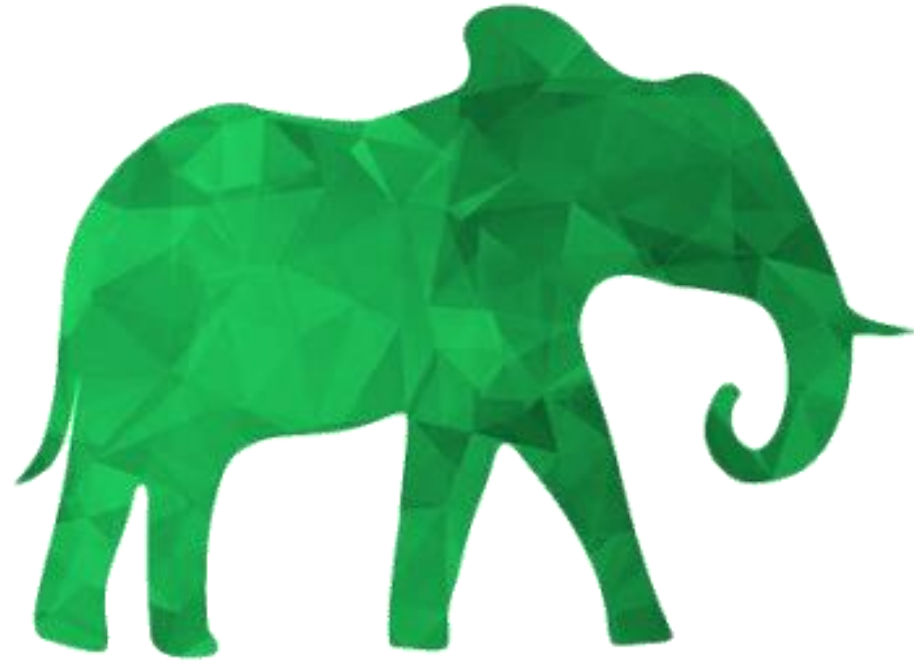
An Elephant in the Light: A Comprehensive Pricing Factors Taxonomy

Pricing approach:

An Elephant in the Light: A Comprehensive Pricing Factors Taxonomy
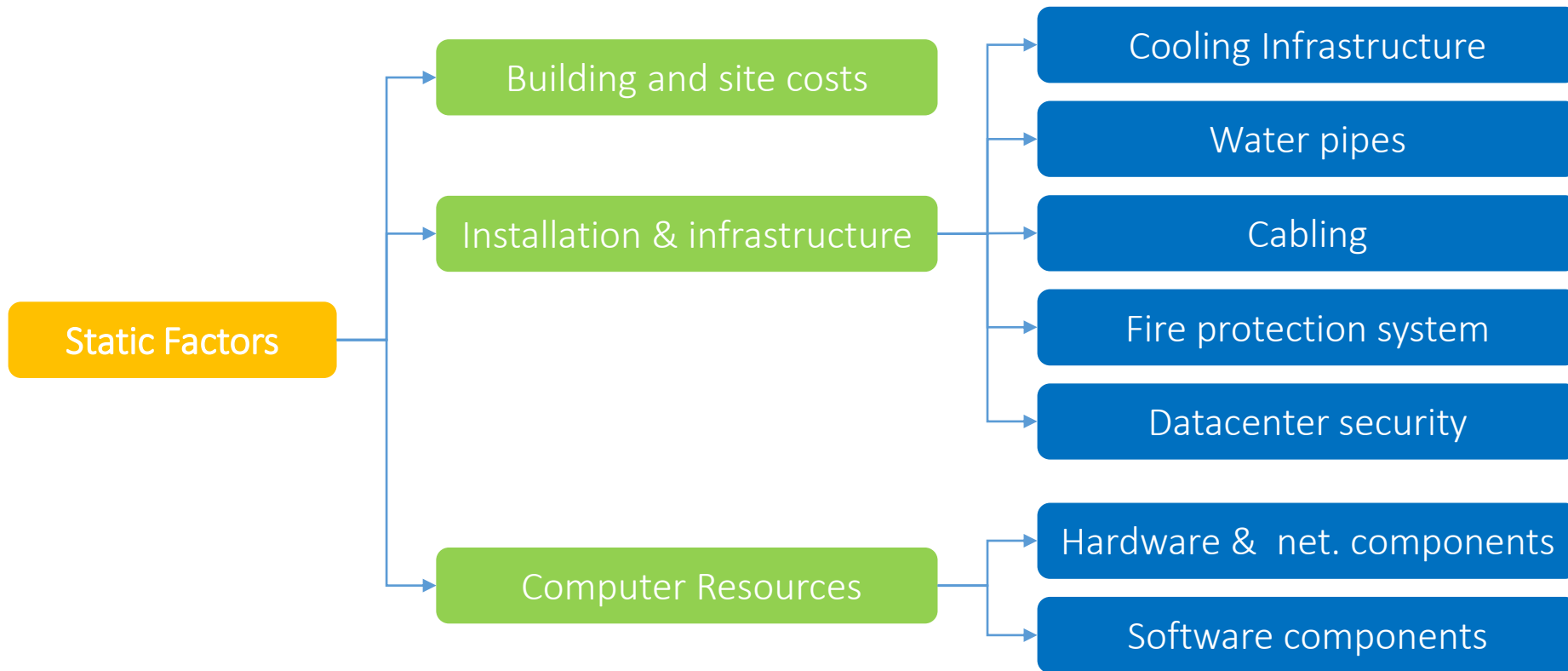
Static Factors

- Building and site costs
- Installation & infrastructure
  - Cooling Infrastructure
  - Water pipes
  - Cabling
  - Fire protection system
  - Datacenter security
- Computer Resources
  - Hardware & net. components
  - Software components

An Elephant in the Light

Dynamic Factors

- Annual prices
  - Annual Taxes
  - Annual building maint. fee
  - Annual infra. maint. fee
- Lease period
- QoS
  - Service availability
  - Service provider's integrity
  - Scalability
    - App. architecture
    - Hardware
    - Network
  - Security level
    - Confidentiality
    - Data integrity
    - Control & Audit
  - Privacy
  - SLA violation penalty
- Performance evaluation
- System failure
  - Hardware failure
  - Network failure
  - Software failure

An Elephant in the Light

Dynamic Factors

- Technical maintenance
  - Salary of employees
    - Full-time
    - Part-time
  - Outsourcing tech. problems
- Computer Resources
  - Hardware & net. components
    - Improvement
    - Replacement
    - Repairment
  - Software components
    - Scale up
    - Scale out
- Green source of energy
  - Energy source classification
    - Fossil fuel & nuclear
    - Renewable energy
- Electricity cost
  - Customer classification
- Resource idle time
  - Process type
    - Time-flexible process
    - Time-sensitive process
  - Greenness of the sources
- Geographical location
  - Server idle time
- Fairness
  - Virtual Machine idle time
- Competitors
  - Available service locations
- Market demand
  - Service calc. based on dist.

CLOUD

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Contribution One:

Sustainable Fair Pricing Mechanism

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Related Work for Contribution One

For Static
- Autonomic metered pricing for a utility computing service → High-demand and Low-demand
- Using formulas
- Comparing Cloud Service prices vs in-home service prices
- Correlation between the cloud service level and the offered price
- Revenue optimization and Price discrimination → User classification and Resource usage
- Pricing Model and Simulation of Public Cloud Services → Bandwidth and Network congestion
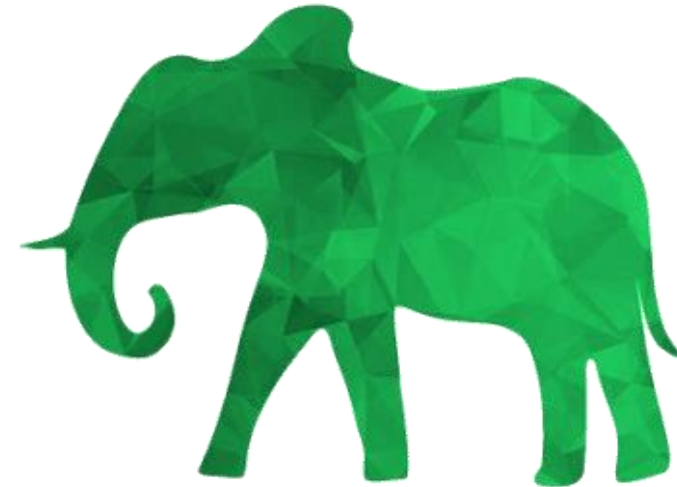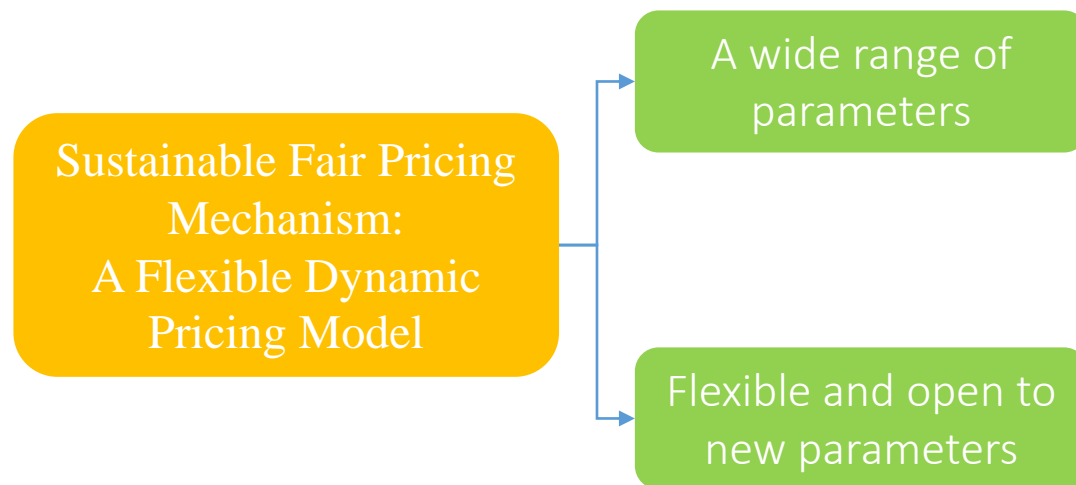
For Dynamic
- Spot Instance

Related Work for Contribution One

Why we need something better?

👎 Most of the studies concentrated on one or a few features.

👍 A flexible dynamic pricing mechanism will be declared in the current thesis.

Sustainable Fair Pricing Mechanism:
A Flexible Dynamic Pricing Model

→ A wide range of parameters

→ Flexible and open to new parameters

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My Methodology for Contribution One
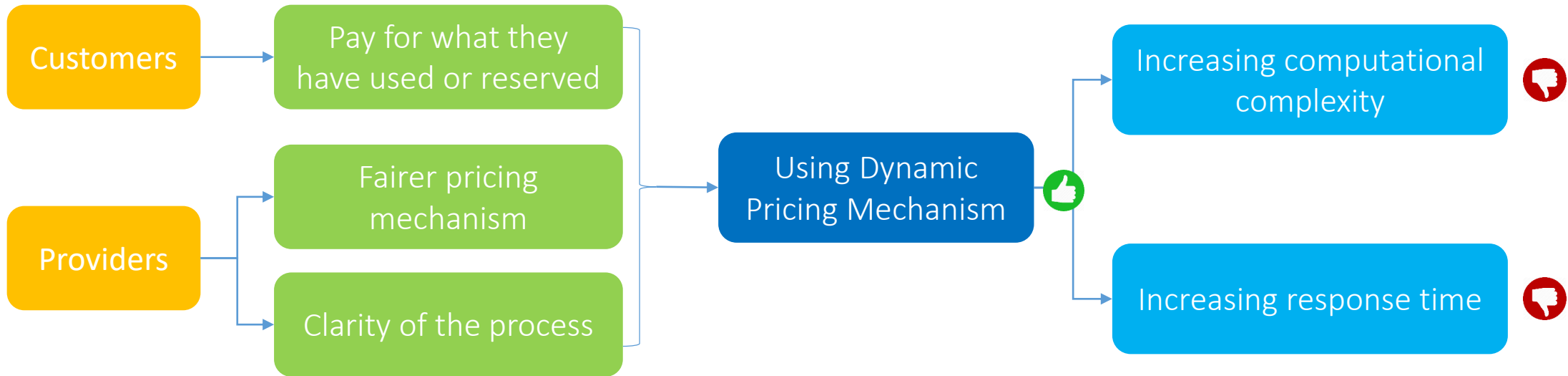
My Methodology for Contribution One

Pricing and revenue optimization [42]:

Maximizing Cloud Providers Revenue		
↓		
Dynamic Pricing mechanism is mandatory	→ Prerequisites for Dynamic Pricing Mechanism	→ The system experiences variable, but predictable demands
		→ Its capacity for providing services is fixed
		→ Resources are wasted if not used
		→ Service providers are able to regulate the prices

My Methodology for Contribution One

Step 1: Users Classification

Main type of users for Cloud Services:

Lower service prices for all users

Better resource estimation for providers

Subscribed users

# of Days * 24 hours

Ad hoc users

# of hours

Higher benefit in shorter time for providers

Affordable service price for limited usage

Total service hours purchased by users

My Methodology for Contribution One

Step 1: Users Classification

Calculating service hours for subscribed and ad hoc users:

$Service \quad hours \quad for \quad subscribed \quad users \quad (S_uS_h) : (Number of days) * 24$

$Service \quad hours \quad for \quad ad \quad hoc \quad users \quad (A_uS_h) : Number of hours$

Total service hours in the cloud (T_uS_h): Service hours for subscribed users + Service hours for ad hoc users

$$T_uS_h = S_uS_h + A_uS_h$$

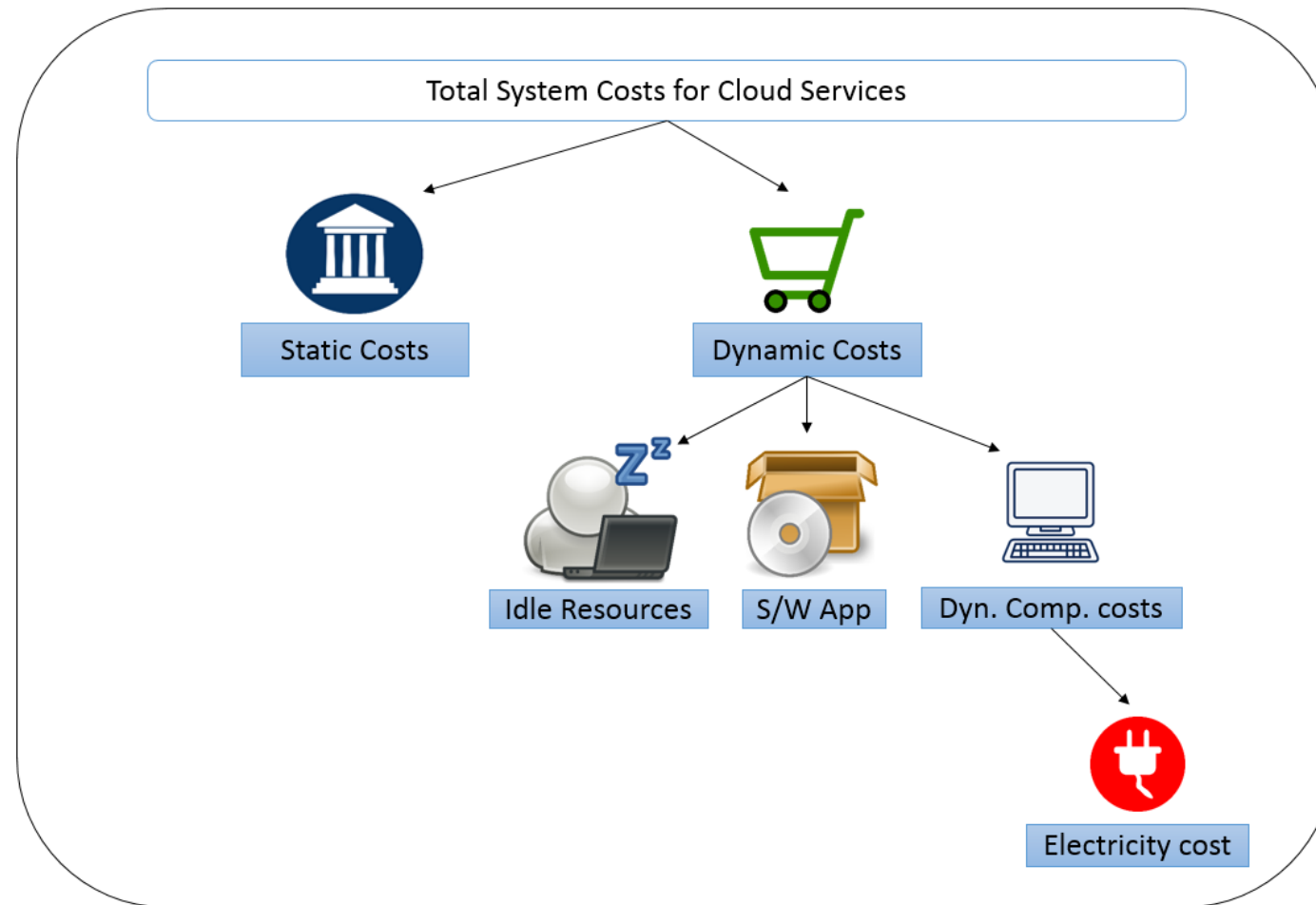# My Methodology for Contribution One

How to calculate total costs:

My Methodology for Contribution One

Step 2: Calculating Static Costs
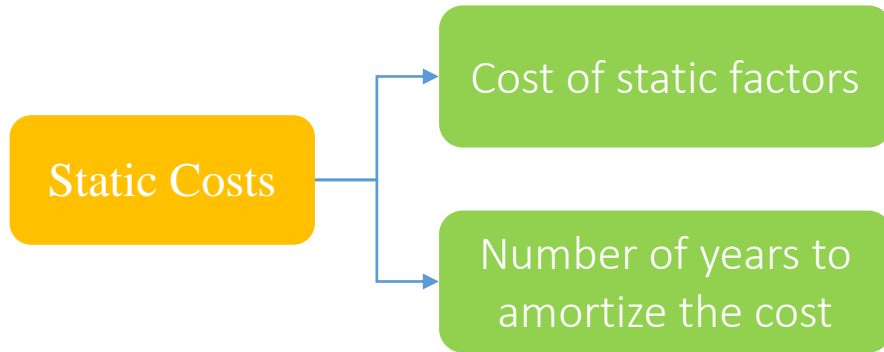
Static Costs

Cost of static factors

Number of years to amortize the cost

$$St_Y = \sum_{i=1}^{n} (St_i / Y_i)$$

The number of years that expected that static factor to be amortized

The static item number i

The summation of all static factors that should be amortized in a year

My Methodology for Contribution One

Step 3: Calculating Dynamic Costs (Part I: Calculating idle resources costs)
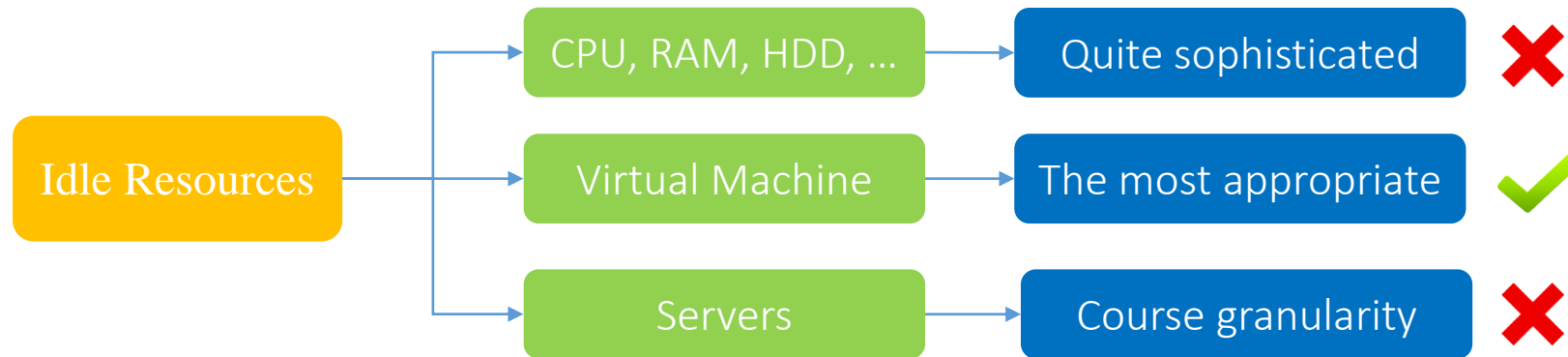
My Methodology for Contribution One

Step 3: Calculating Dynamic Costs (Part I: Calculating idle resources costs)

The cost of the total amount of idle resources (VMs) could be calculated as follows:

$$IR_h = \sum_{i=1}^{n} BVM_h$$

total cost of idle resources

the cost of total number of hours that basic VMs are idle in a year

My Methodology for Contribution One

Step 3: Calculating Dynamic Costs (Part II: Calculating software application costs)

If a user uses a software 365 days * 24 hours → We should ask for 10% of the original price for a whole year
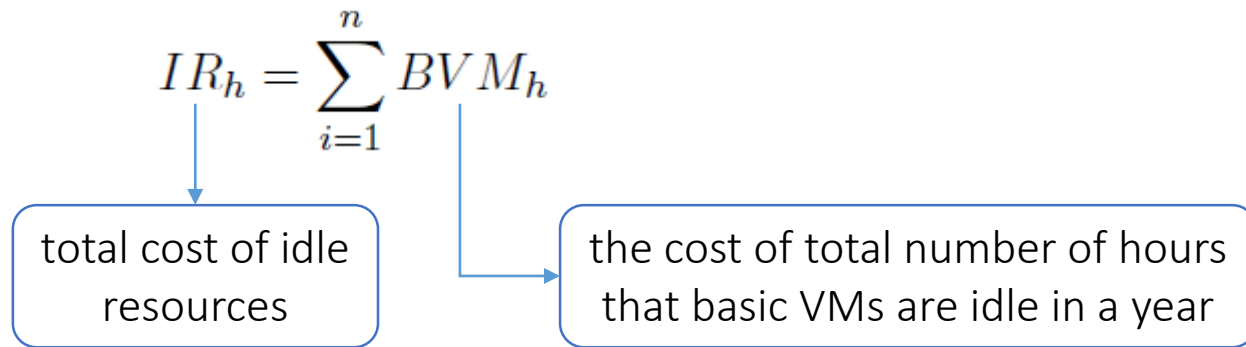
My Methodology for Contribution One
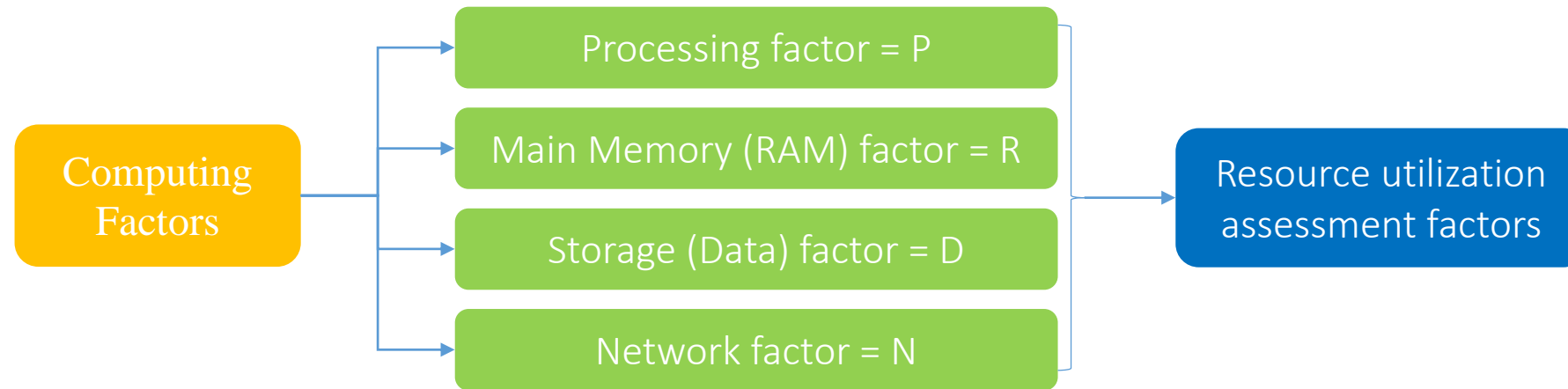
Step 3: Calculating Dynamic Costs (Part III: Calculating dynamic computing costs)

My Methodology for Contribution One

Step 3: Calculating Dynamic Costs (Part III: Calculating dynamic computing costs)

$$X = (\alpha P + \beta R + \gamma D + \theta N) \times h$$

The total dynamic costs, including the electricity in one year

\# of hours

$$X = \sum_{i=1}^{n} Dyn = (\alpha P + \beta R + \gamma D + \theta N) \times h$$

Measurable
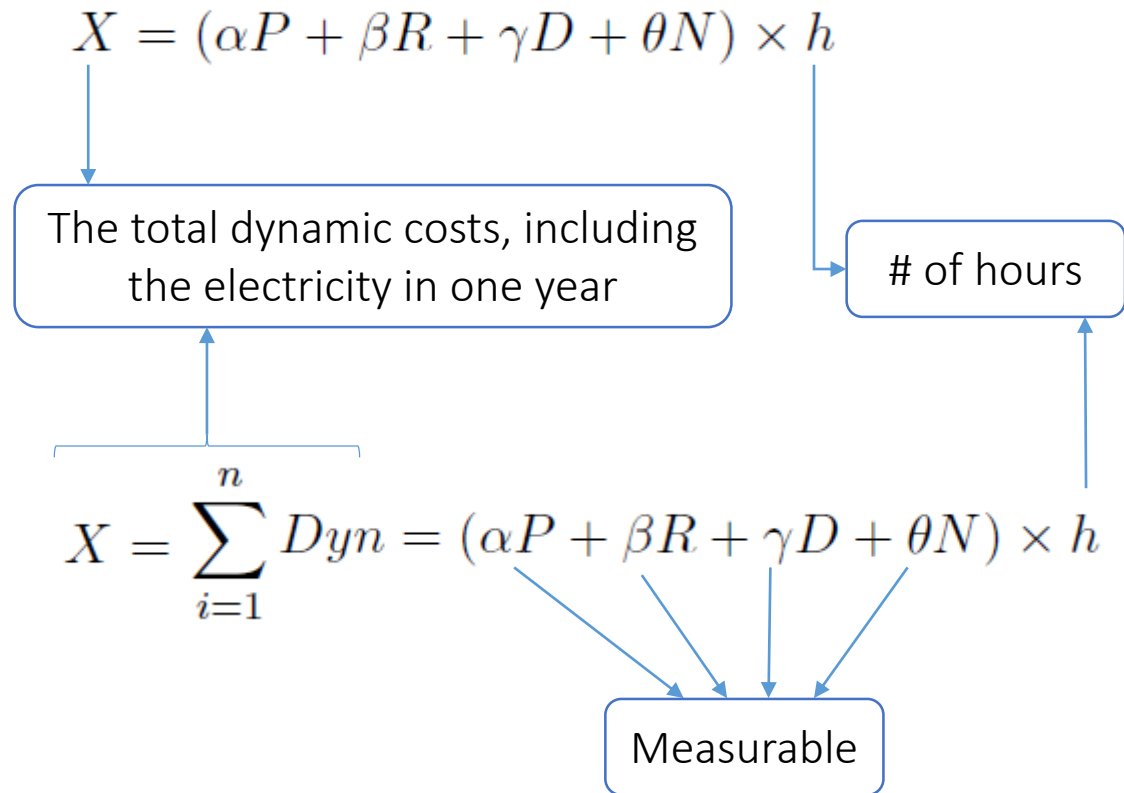
My Methodology for Contribution One

Step 3: Calculating Dynamic Costs (Part IIII: Including electricity costs)

For this step we should calculate the ratio of electricity consumption over the total dynamic costs.

$$Ratio \quad of \quad electricity \quad cost \quad (high \quad price) \quad over \quad Total \quad dynamic \quad costs = \frac{\sum Elec}{\sum_{i=1}^{n} Dyn}$$

My Methodology for Contribution One

Summarizing all the steps: (Figure #01)
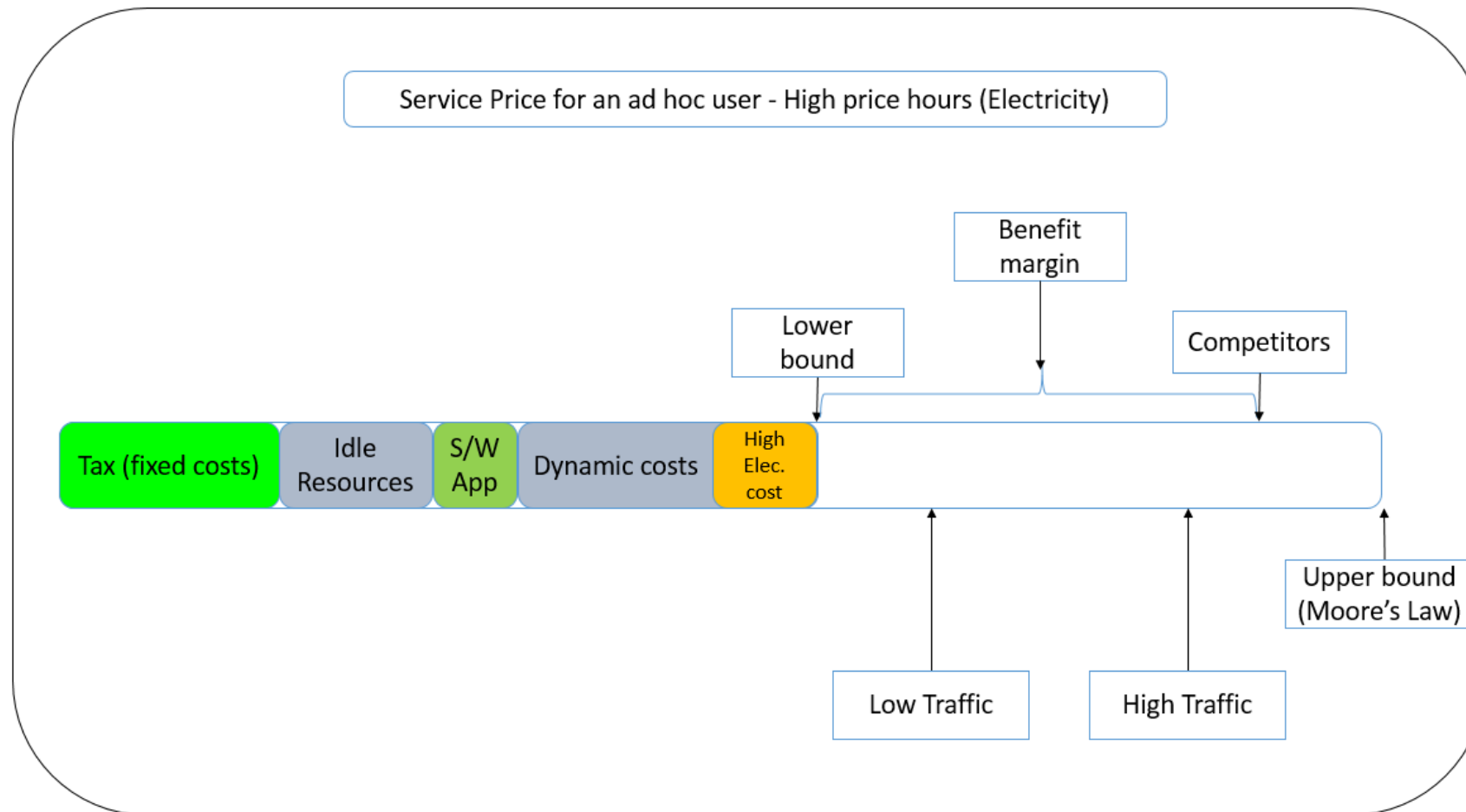
My Methodology for Contribution One

Summarizing all the steps: (Figure #02)
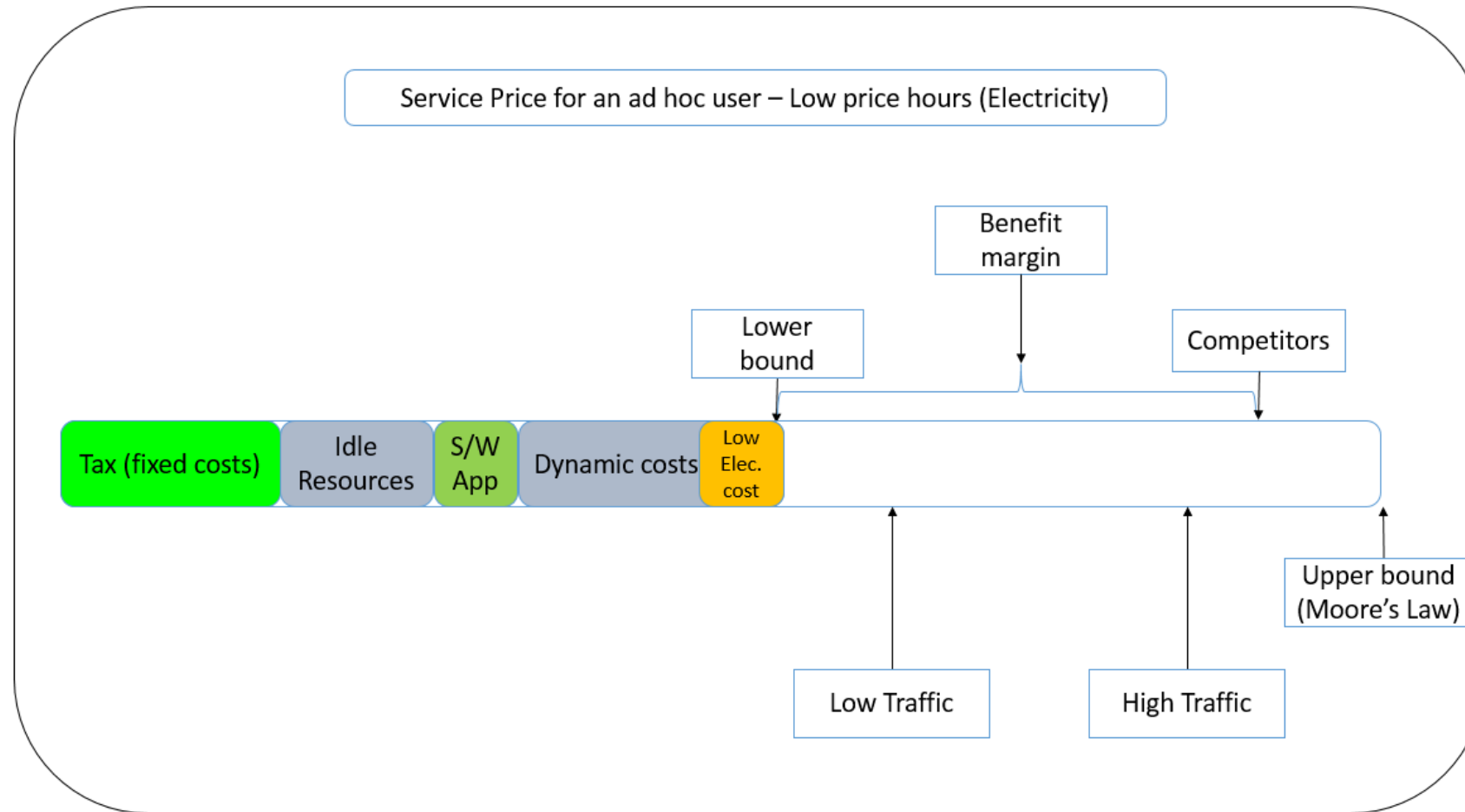
My Methodology for Contribution One

Summarizing all the steps: (Figure #03)
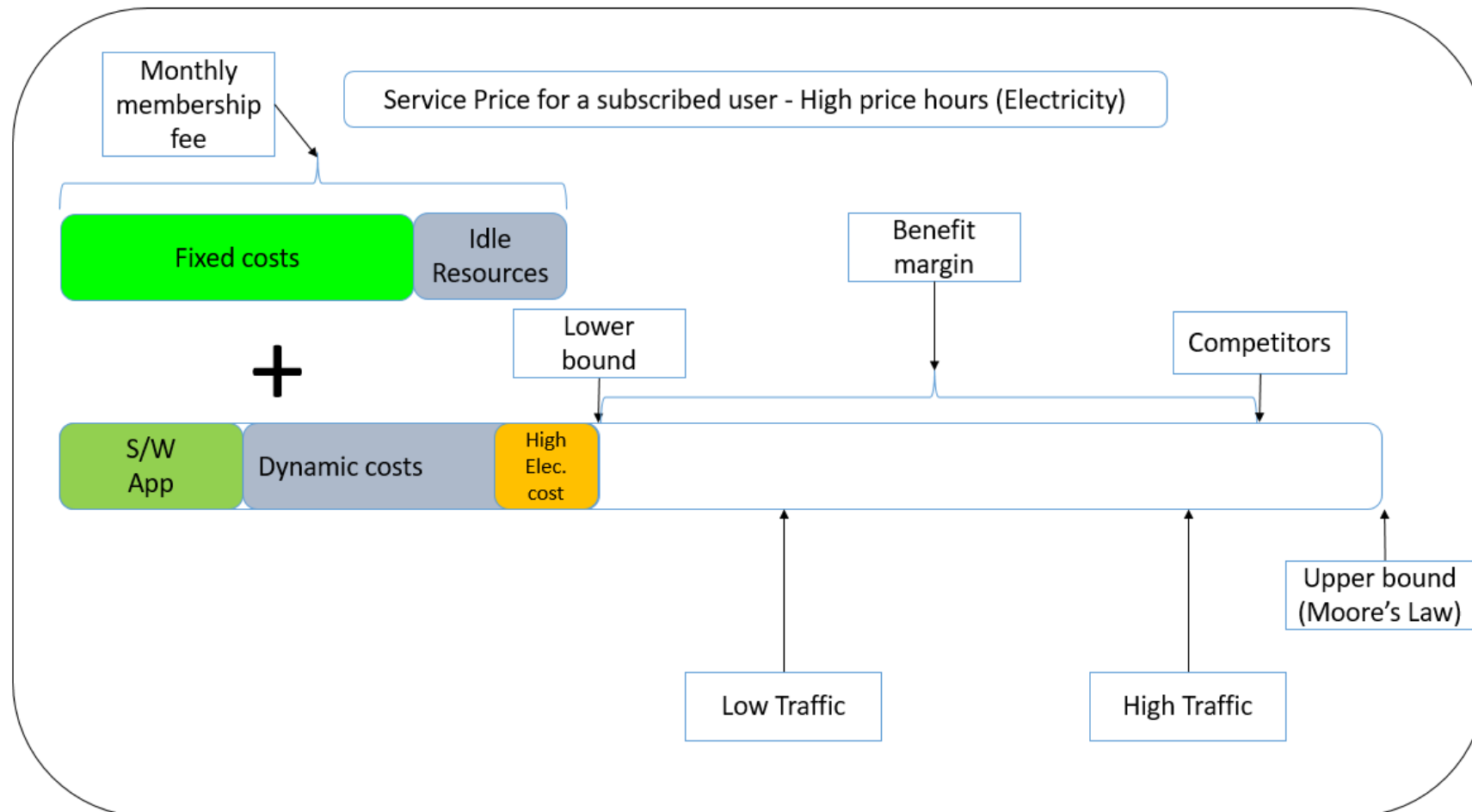
My Methodology for Contribution One

Summarizing all the steps: (Figure #04)
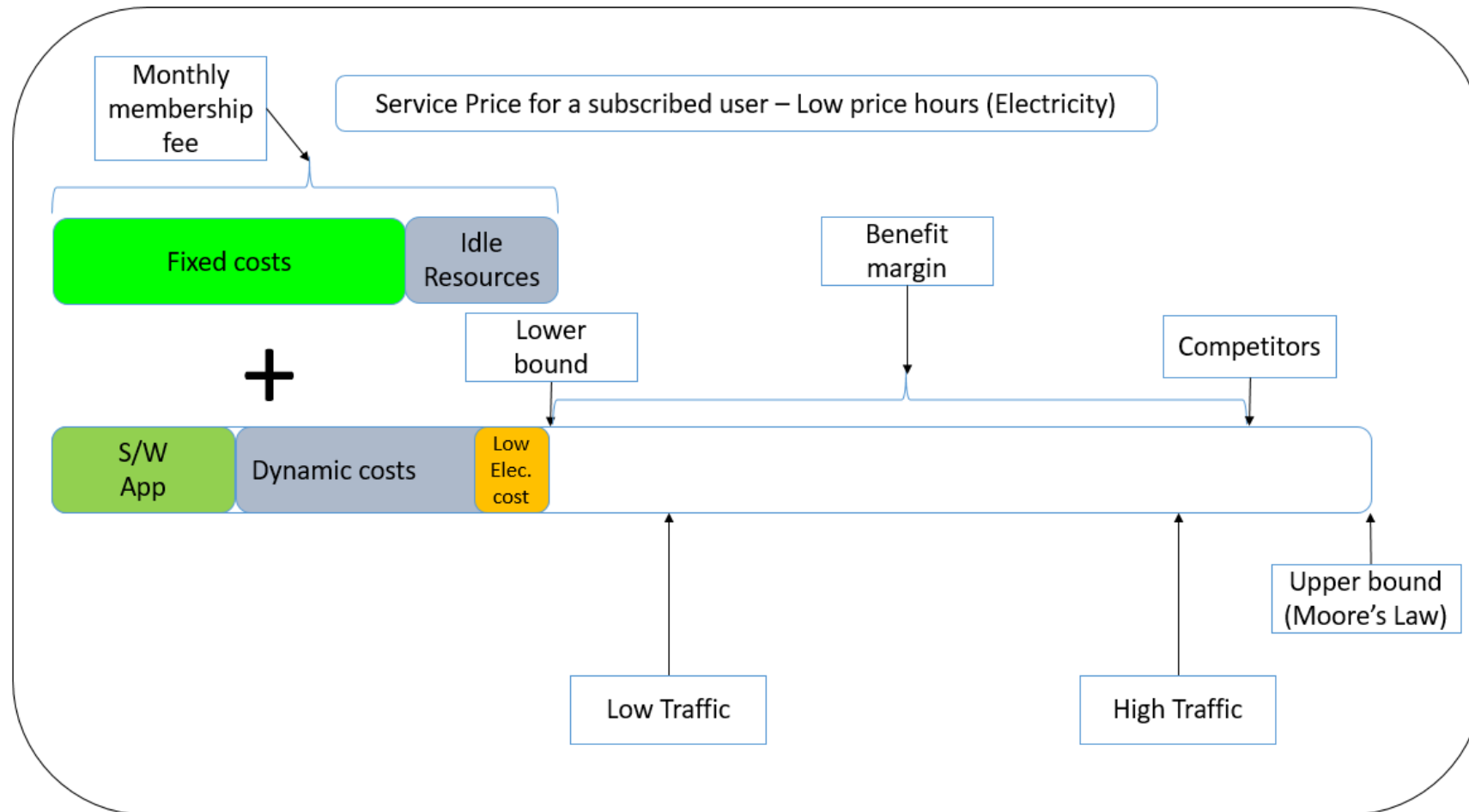
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Contribution Two:

Dynamic Resource Allocation (DRA)

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Introduction to Contribution Two

Why do we need to change configuration?

```
                          ┌──────────────────────────────────┐
                          │         Energy efficiency         │
                          └──────────────────────────────────┘
                          ┌──────────────────────────────────┐
┌──────────────────┐      │   Improving resource utilization  │
│ Changing Resource│      └──────────────────────────────────┘
│    Allocation    │      ┌──────────────────────────────────┐
└──────────────────┘      │     Applications' optimization    │
                          └──────────────────────────────────┘
                          ┌──────────────────────────────────┐
                          │          Cost reduction           │
                          └──────────────────────────────────┘
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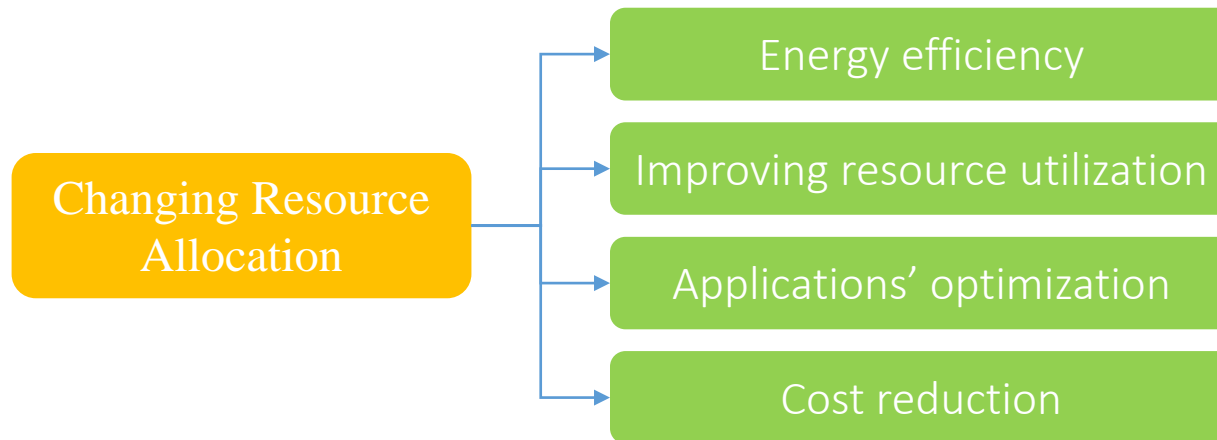
Introduction to Contribution Two

Why do we need to change configuration?
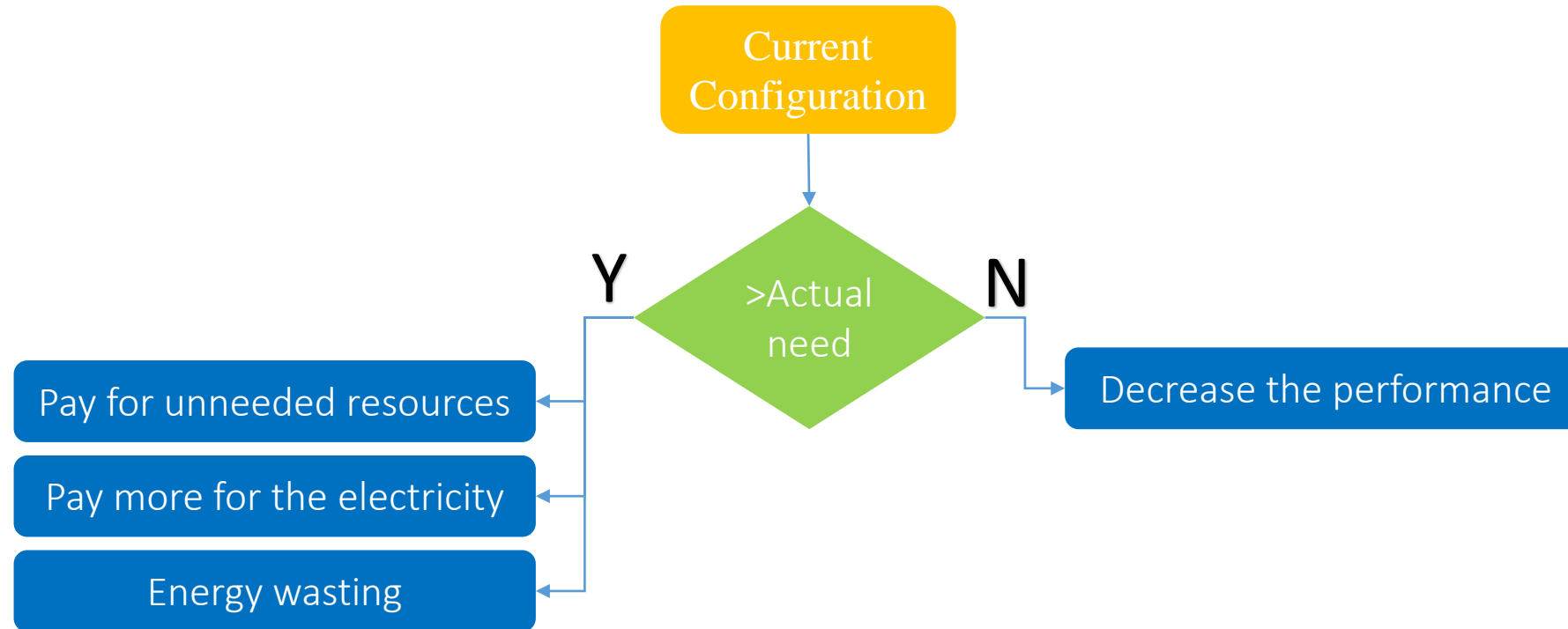
Introduction to Contribution Two

How we initially configure our systems?
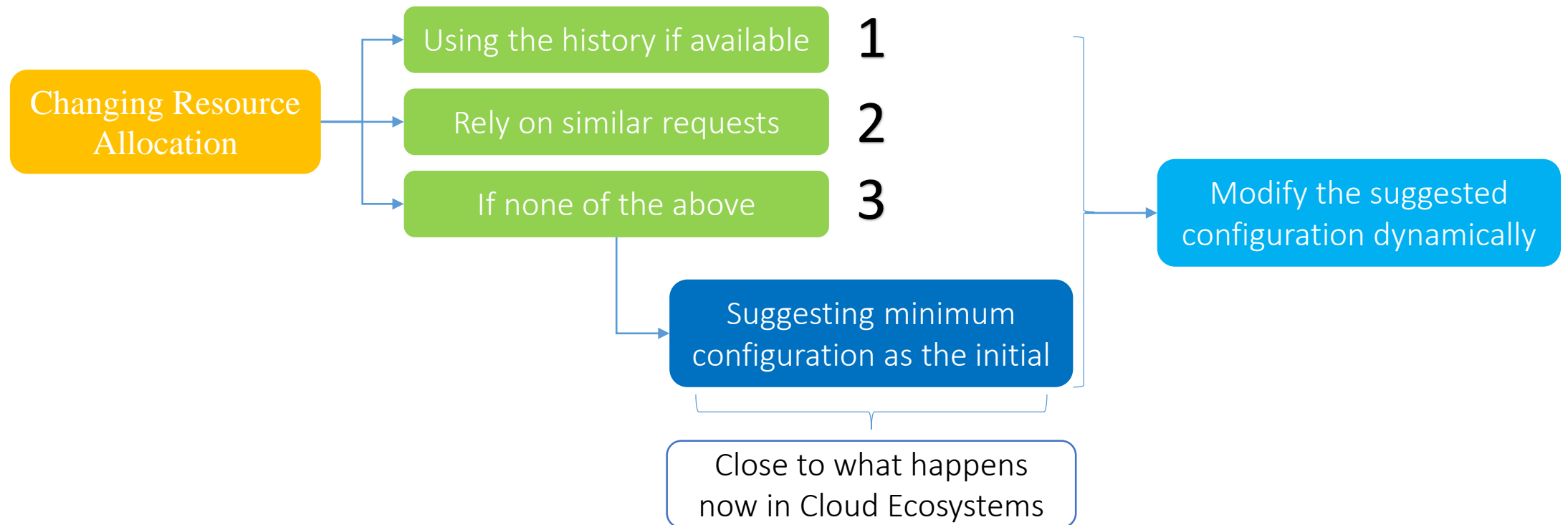
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My Methodology for Contribution Two

The methodology for the current thesis

Current Thesis Methodology

Using the collected data to evaluate the cloud service performance

To tune the configuration automatically and dynamically

My Methodology for Contribution Two

Any system that needs to adjust itself has to have a strategy.

In this part of thesis contribution, we use two different methods:
- MAPE-K
- Amazon Lambda

My Methodology for Contribution Two

MAPE-K from IBM
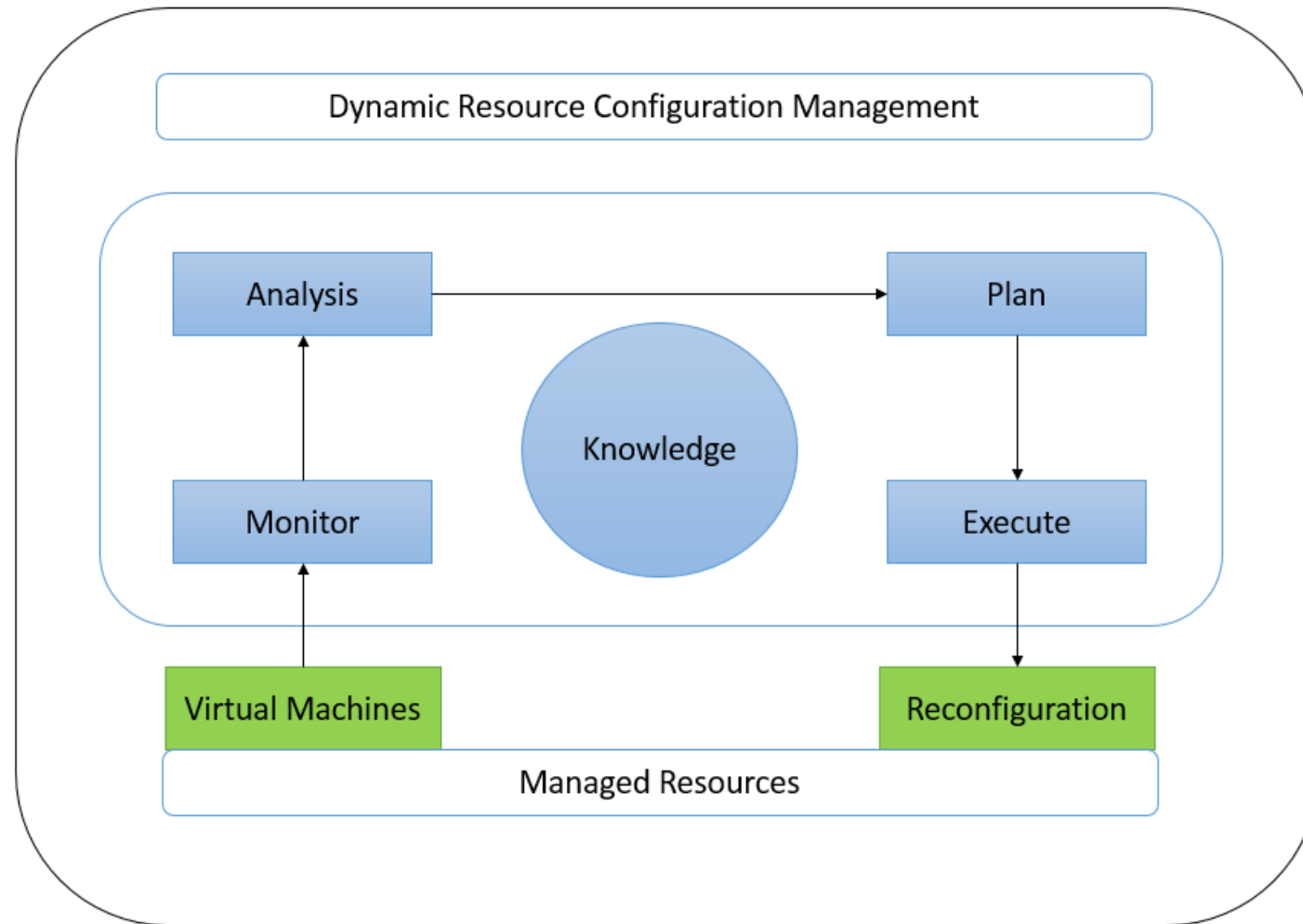
My Methodology for Contribution Two

If the configuration needs to consider both historical data as well as the recent changes, normally two window frames needed to be considered:

Evaluating the System → Two window frames → Long-term window frames / Short-term window frames
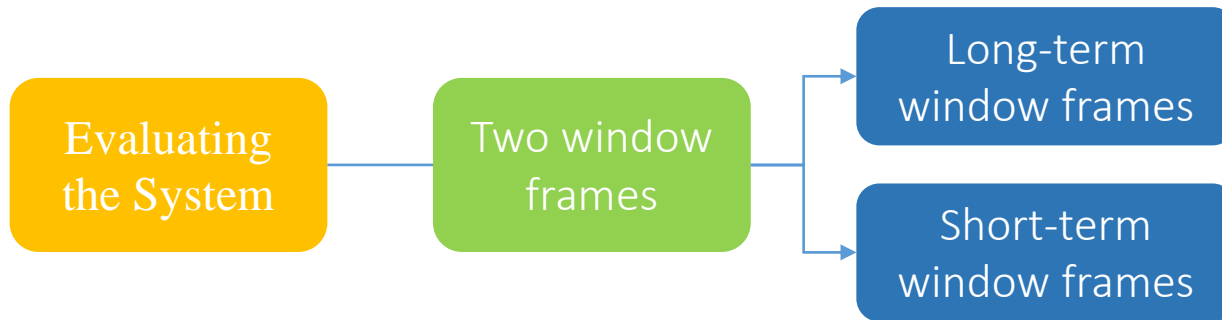
My Methodology for Contribution Two

How Amazon Lambda's solution improves pricing approaches?
Amazon Lambda is a software design pattern that responses to online and batch processes in a single framework [49].
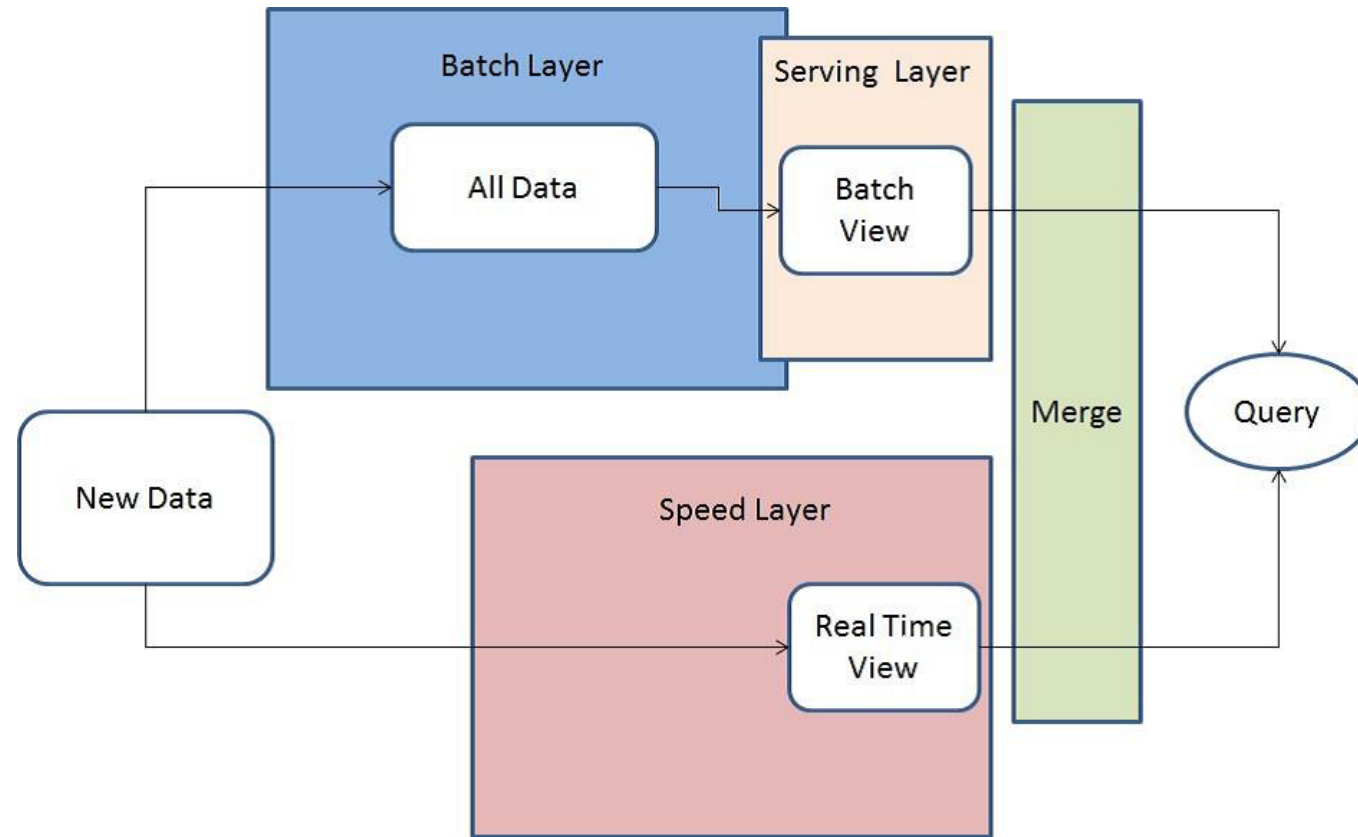
My Methodology for Contribution Two

How to apply Amazon Lambda's architecture?
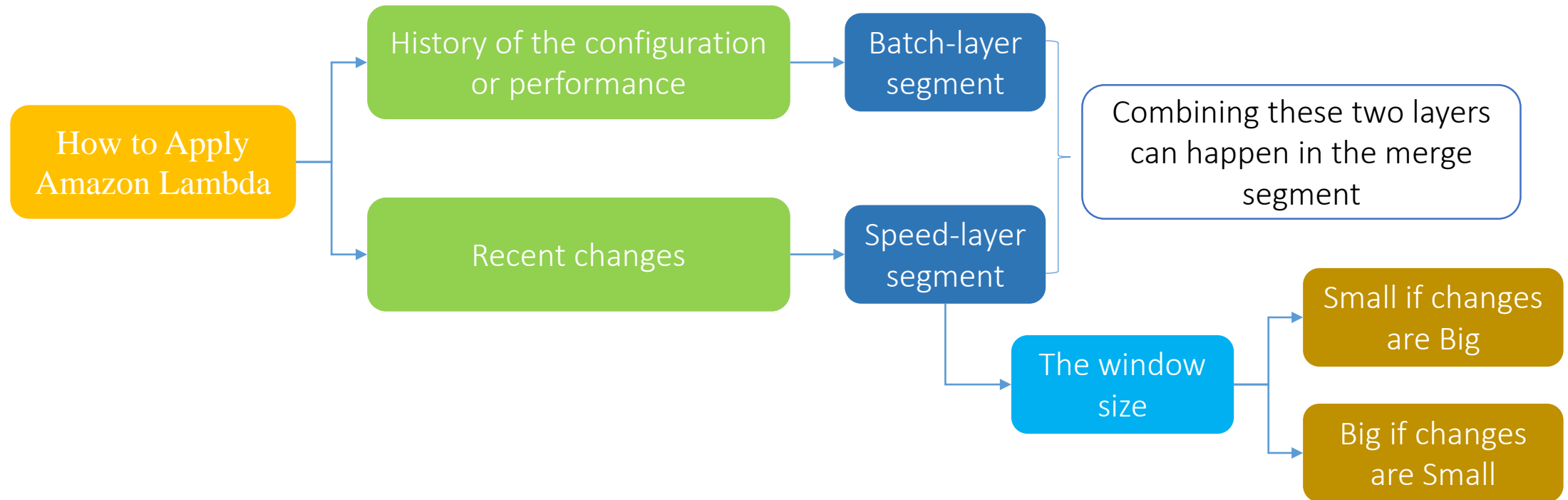
```
How to Apply Amazon Lambda
    ├── History of the configuration or performance ──> Batch-layer segment ──┐
    │                                                                          ├──> Combining these two layers can happen in the merge segment
    └── Recent changes ──> Speed-layer segment ──┬────────────────────────────┘
                                                  │
                                                  └──> The window size ──┬──> Small if changes are Big
                                                                         └──> Big if changes are Small
```

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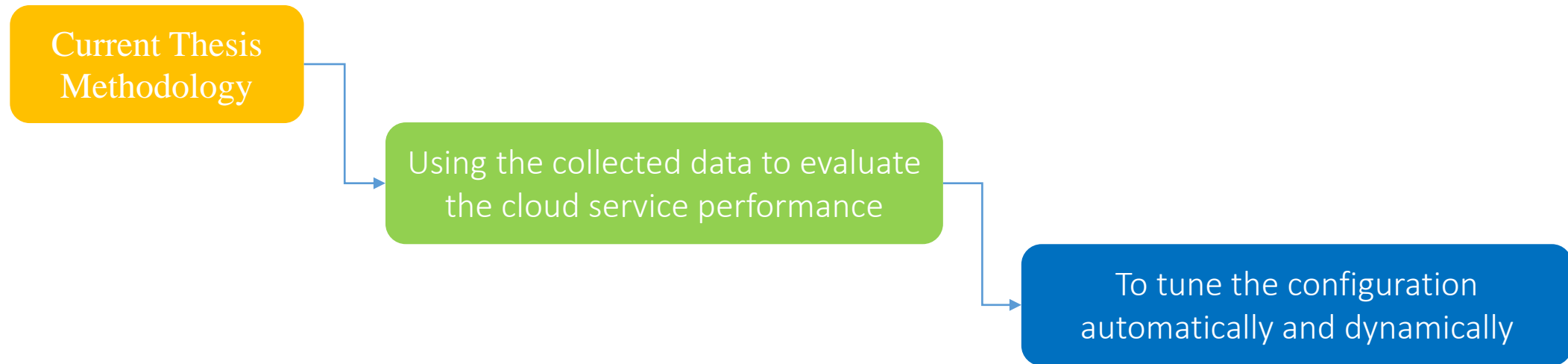 - Introduction to Contribution Two
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- **References**

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Published. https://www.nist.gov/news-events/news/2011/10/
final-version-nist-cloud-computing-definition-published, Oct 2011. Accessed: 2017-11-23.

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Thank you For your attention

Backup Slides

Pricing Factors Taxonomy in Details

#	Level 1	Level 2	Level 3	Dir. Fin. Equ.	Indir. Fin. Equ.	Msr.	Wght.	Cplx.
1	Static							
2		Building and site costs		Yes	Yes	Yes	Yes	No
3		Installation and infrastructure		Yes	N/A	N/A	N/A	No
4			Cooling Infrastructure	Yes	N/A	N/A	N/A	No
5			Water pipes	Yes	N/A	N/A	N/A	No
6			Cabling	Yes	N/A	N/A	N/A	No
7			Fire protection system	Yes	N/A	N/A	N/A	No
8			Datacenter security	Yes	N/A	N/A	N/A	No
9		Computer resources		Yes	N/A	N/A	N/A	No
10			Hardware components • Server • Storage • Switches/Router • UPS	Yes	N/A	N/A	N/A	No

Pricing Factors Taxonomy in Details

#	Level 1	Level 2	Level 3	Dir. Fin. Equ.	Indir. Fin. Equ.	Msr.	Wght.	Cplx.
11			Software components • Operating systems • Hypervisor • Development environments • Databases and storage • Other software components	Yes	N/A	N/A	N/A	No
12	Dynamic							
13		Annual prices		Yes	N/A	N/A	N/A	No
14			Annual Taxes	Yes	N/A	N/A	N/A	No
15			Annual building maintenance fee	Yes	N/A	N/A	N/A	No

Pricing Factors Taxonomy in Details

#	Level 1	Level 2	Level 3	Dir. Fin. Equ.	Indir. Fin. Equ.	Msr.	Wght.	Cplx.
16			Annual infrastructure maintenance fee • Cooling systems maintenances • Water pipes maintenance • Cabling maintenance • Fire protection system • Datacenter security • Others	Yes	N/A	N/A	N/A	No
17		Lease period		No	Yes	Yes	Yes	Yes
18		QoS						
19			Service availability	No	Yes	Yes	Yes	No
20			Service provider's integrity	No	No	No	Yes	Yes
21			Scalability	No	No	Yes	Yes	Yes
22			Security level	No	Yes	Yes	Yes	No
23			Privacy	No	Yes	Yes	Yes	No

Pricing Factors Taxonomy in Details

#	Level 1	Level 2	Level 3	Dir. Fin. Equ.	Indir. Fin. Equ.	Msr.	Wght.	Cplx.
24			SLA violation penalty (Performance, availability, etc.)	No	Yes	Yes	Yes	No
25		Performance evaluation		No	Yes	Yes	Yes	No
26		System failure		No	No	Yes	Yes	Yes
27			Hardware failure • CPU • Hard Drive • Network Devices	No	No	Yes	Yes	Yes
28			Network failure	No	No	Yes	Yes	Yes
29			Software failure	No	No	Yes	Yes	Yes
30		Technical maintenance						
31			Salary of employees • Full-time • Part-time	Yes	N/A	N/A	N/A	No

Pricing Factors Taxonomy in Details

#	Level 1	Level 2	Level 3	Dir. Fin. Equ.	Indir. Fin. Equ.	Msr.	Wght.	Cplx.
32			Outsourcing technical problems • Contract • Ad-hoc	Yes	N/A	Yes	Yes	Yes
33		Computer resources						
34			Hardware and networking components • Improvement • Replacement • Repairment	Yes	N/A	Yes	Yes	No

Pricing Factors Taxonomy in Details

#	Level 1	Level 2	Level 3	Dir. Fin. Equ.	Indir. Fin. Equ.	Msr.	Wght.	Cplx.
35			Software components • New software licenses • Annual renewal fees • Per transaction • Update • Quantity change (e.g. number of users) • Quality change (e.g. professional version) • Add-ons	Yes	N/A	Yes	Yes	No
36		Green source of energy						
37			Energy source classification	No	Yes	Yes	Yes	Yes
38			Customer classification	No	Yes	Yes	Yes	Yes
39		Electricity cost						

Pricing Factors Taxonomy in Details

#	Level 1	Level 2	Level 3	Dir. Fin. Equ.	Indir. Fin. Equ.	Msr.	Wght.	Cplx.
40			Process type • Time flexible processes • Time sensitive processes	Yes	Yes	Yes	N/A	Yes
41			Greenness of the sources	No	Yes	Yes	Yes	Yes
42		Resource idle time		No	Yes	Yes	Yes	Yes
43			Server idle time	No	Yes	Yes	Yes	Yes
44			Virtual Machine idle time	No	Yes	Yes	Yes	Yes
45		Geographical location		No	Yes	Yes	Yes	Yes
46			Available services based on locations	No	N/A	N/A	N/A	No
47			Service calculation based on distance	No	Yes	Yes	Yes	Yes
48		Fairness		No	No	No	Yes	Yes
49		Competitors		No	Yes	Yes	Yes	Yes
50		Market demand		No	No	Yes	Yes	Yes