Cost-Efficient Deployment of Big Data Applications on Clouds

Dr. Rajkumar Buyya

Cloud Computing and **D**istributed **S**ystems (CLOUDS) Lab
Department of Computing and Information Systems
The University of Melbourne, Australia

www.cloudbus.org
www.buyya.com
www.manjrasoft.com

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Innovative Solutions for Cloud Computing

Dr Rajkumar Buyya
Chief Executive Officer

Manjrasoft Pty Ltd
Office No. 7.22, Doug McDonell Building
Melbourne University - Parkville Campus
Melbourne, VIC 3010, Australia
P: +61-3-8344 1344 | M : +61-431799078
E: raj@manjrasoft.com | W: *http://www.manjrasoft.com*

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The Next Revolution in IT
The Big Switch in IT

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The Next Revolution in IT
The Big Switch in IT

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- Classical Computing
  - Buy & Own
    - Hardware, System Software, Applications often to meet peak needs.
  - Install, Configure, Test, Verify
  - Manage
  - ..
  - Finally, use it
  - $$$$....$(High CapEx)

Every 18 months?

The Next Revolution in IT
The Big Switch in IT

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  - ..
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Every 18 months?

- Cloud Computing
  - Subscribe
  - Use

  - $ - pay for what you use, based on QoS

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Outline

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- "Computer Utilities" + Big Data
  - Vision and Promising IT Paradigms

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  - System View, Applications, Challenges, Models

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“Computer Utilities” Vision: Implications of the Internet

"Computer Utilities" Vision: Implications of the Internet

- 1969 – Leonard Kleinrock, ARPANET project
  - "As of now, computer networks are still in their infancy, but as they grow up and become sophisticated, we will probably see the spread of "Computer Utilities", which, like present electric and telephone utilities, will service individual homes and offices across the country".
  - During the last 45 years, several advances have taken place in both "computing" and "communications" areas that are turning the vision of "Computer Utilities" in to a reality.

Computing Paradigms and Attributes: Realizing the 'Computer Utilities' Vision

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- …
- Web
- Data Centres
- Service Computing
- Grid Computing
- P2P Computing
- **Market-Oriented Computing**
- ..
- **Cloud Computing**
- **Big Data**

Paradigms

+

-Ubiquitous
-Reliable
-Scalable
-Autonomic
-Dynamic discovery
- Composable
-QoS
-SLA
- …

Attributes/Capabilities

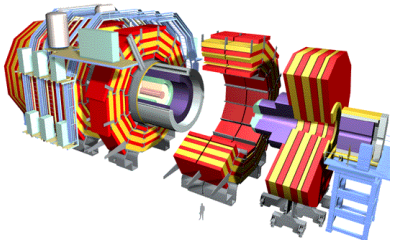
?

-Trillion $ business

A Data-Driven World

Big Data for

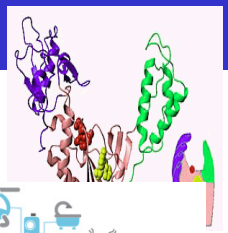
Big Science



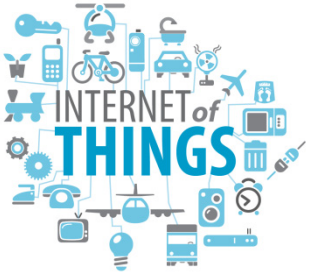
Big Data/Clouds for

Big Population

A Data-Driven World



- Science and Engineering
  - Data from astronomy, genomics, bioinformatics …



- Business and Commerce
  - Corporate sales, stock market trans., airline traffic…

- Entertainment and Social Media
  - Internet images, movies, Social networks …

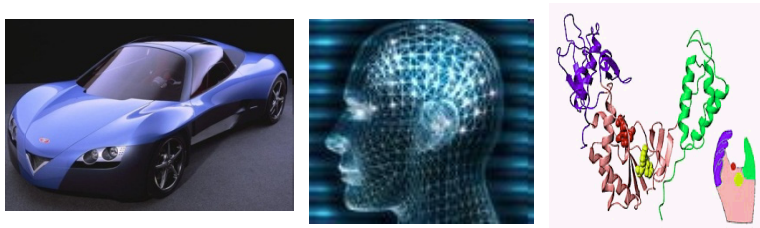
- Medicine and Healthcare
  - MRI & CT scans, patient records, sports data …

- Education and Training
  - T&L experiences, performance, on-line courses …

- Government and Services
  - "Right" services, security, tax, economic,.. policies through government data analytics

Cloud Applications

- Scientific/Tech Applications
- **Business Applications**
- **Consumer/Social Applications**

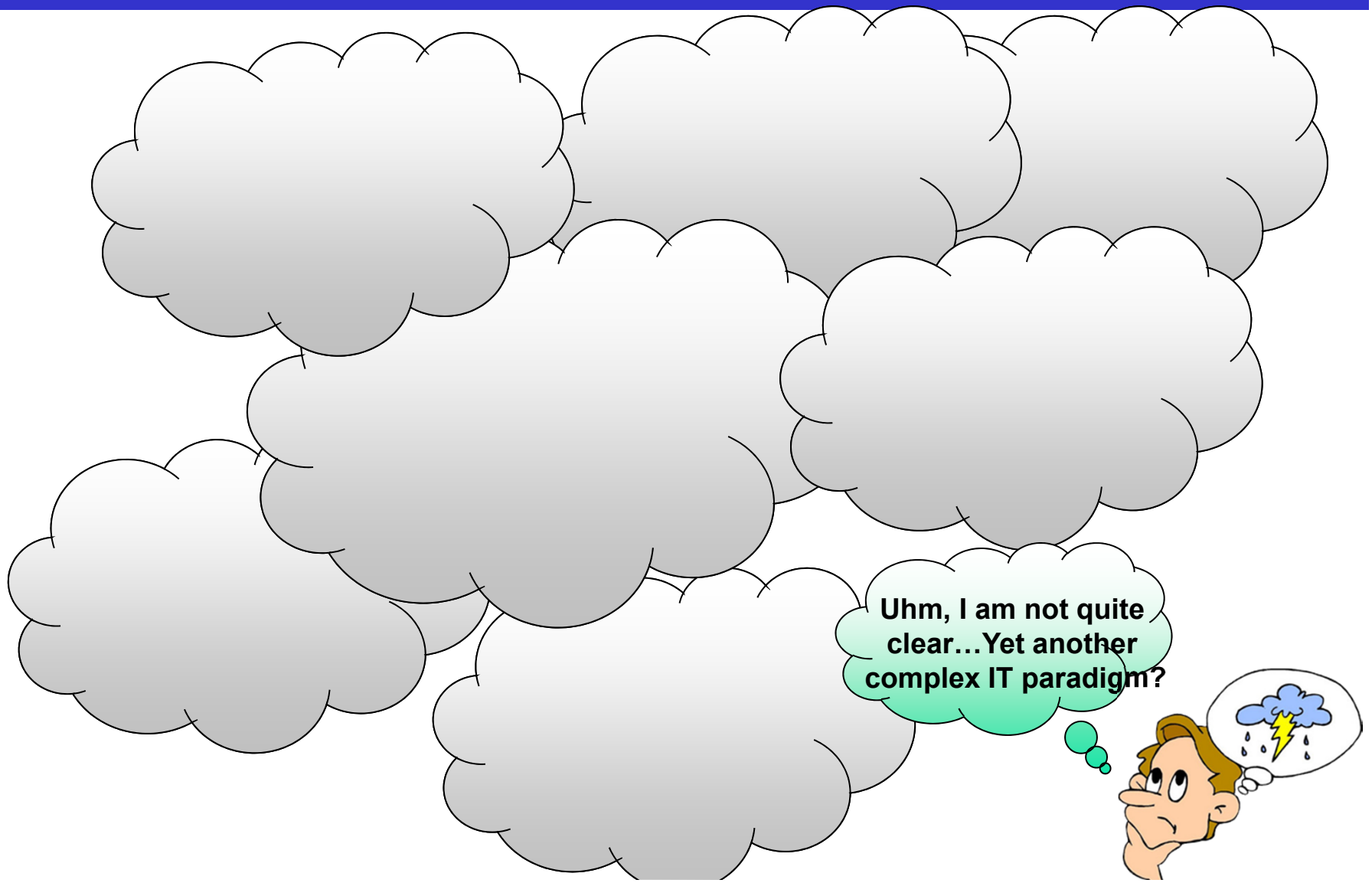


Science and Technical Applications

Business Applications

Consumer/Social Applications

Challenges when you move to Clouds: Too many issues



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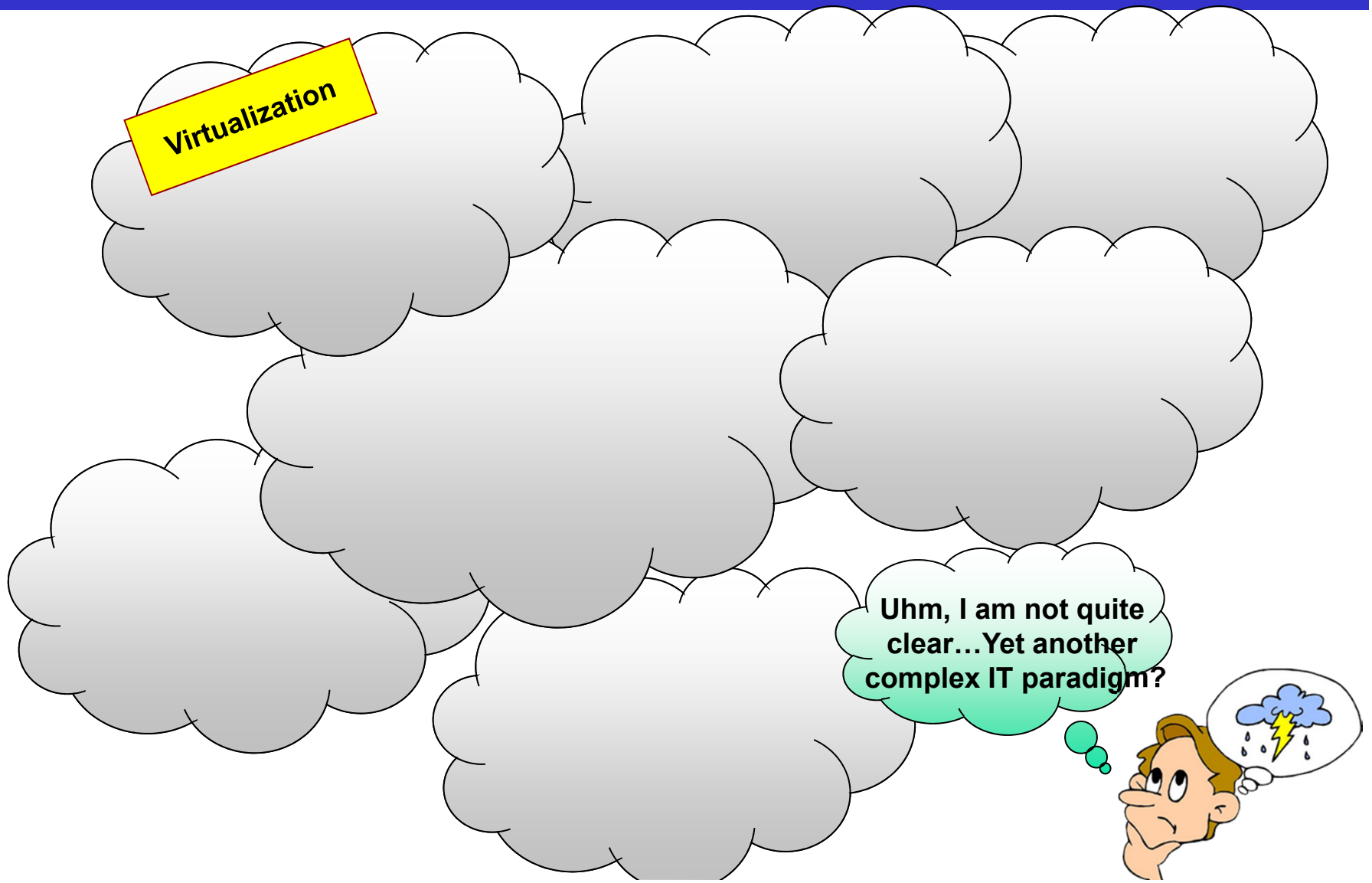

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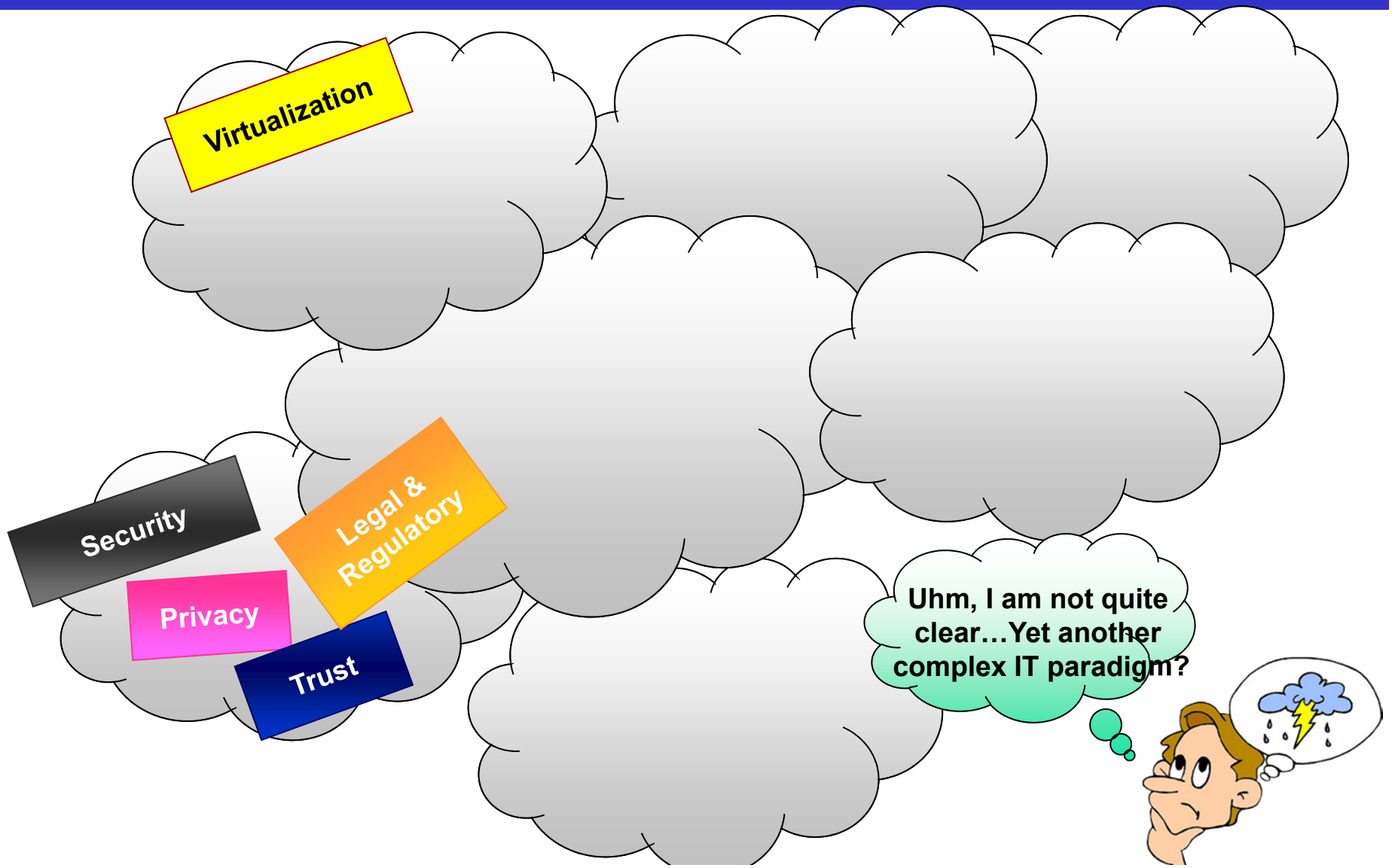

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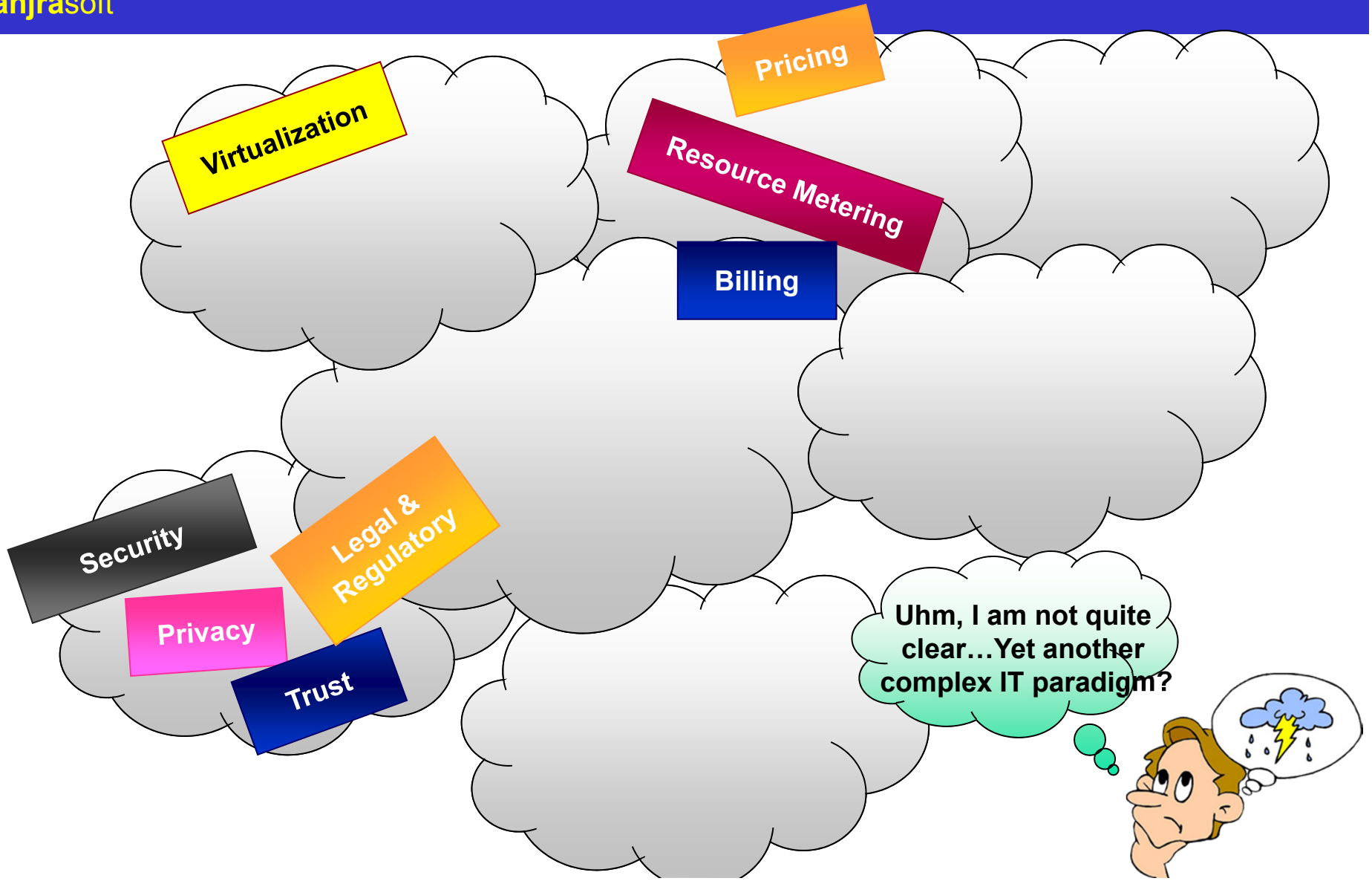

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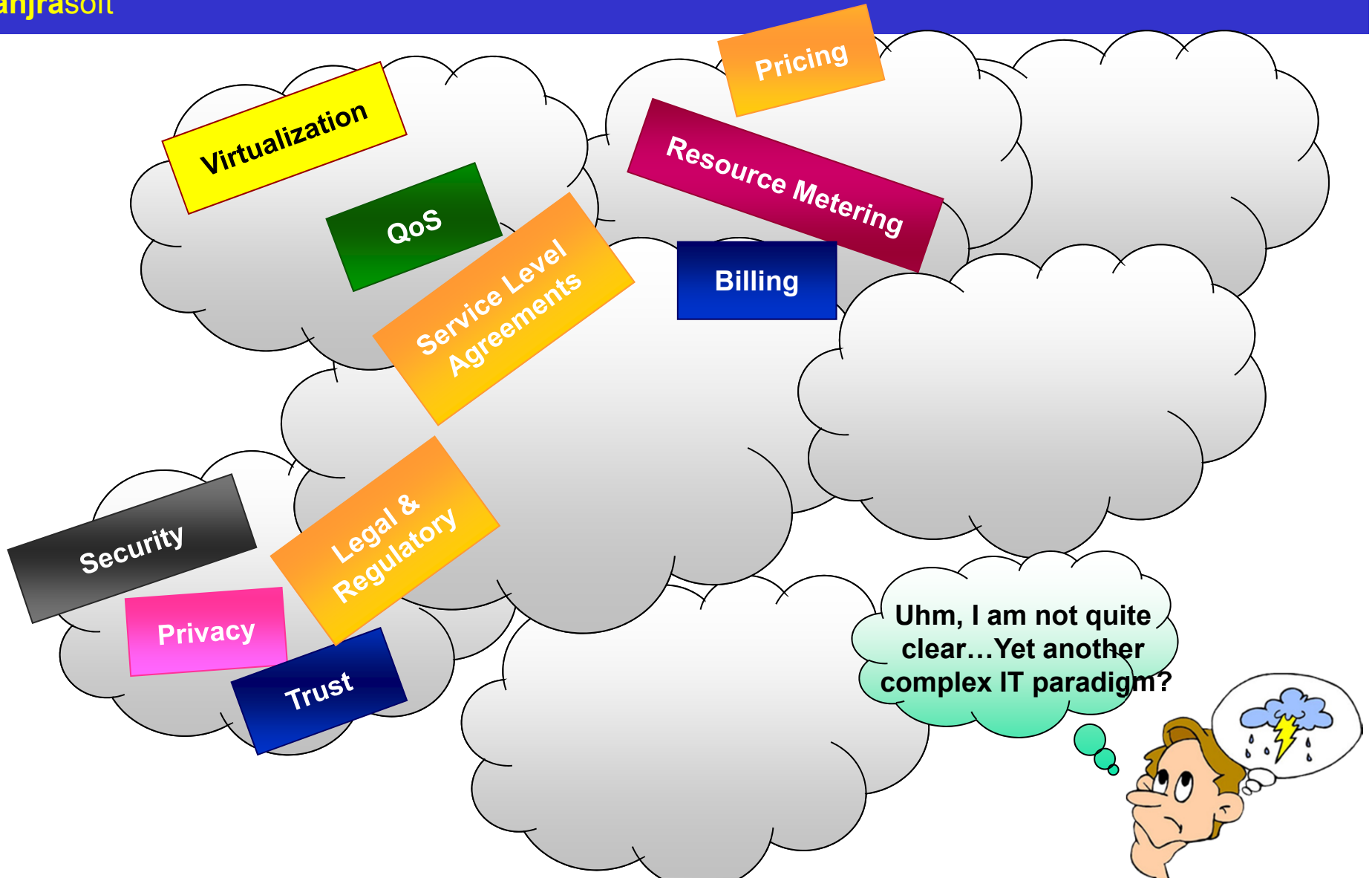

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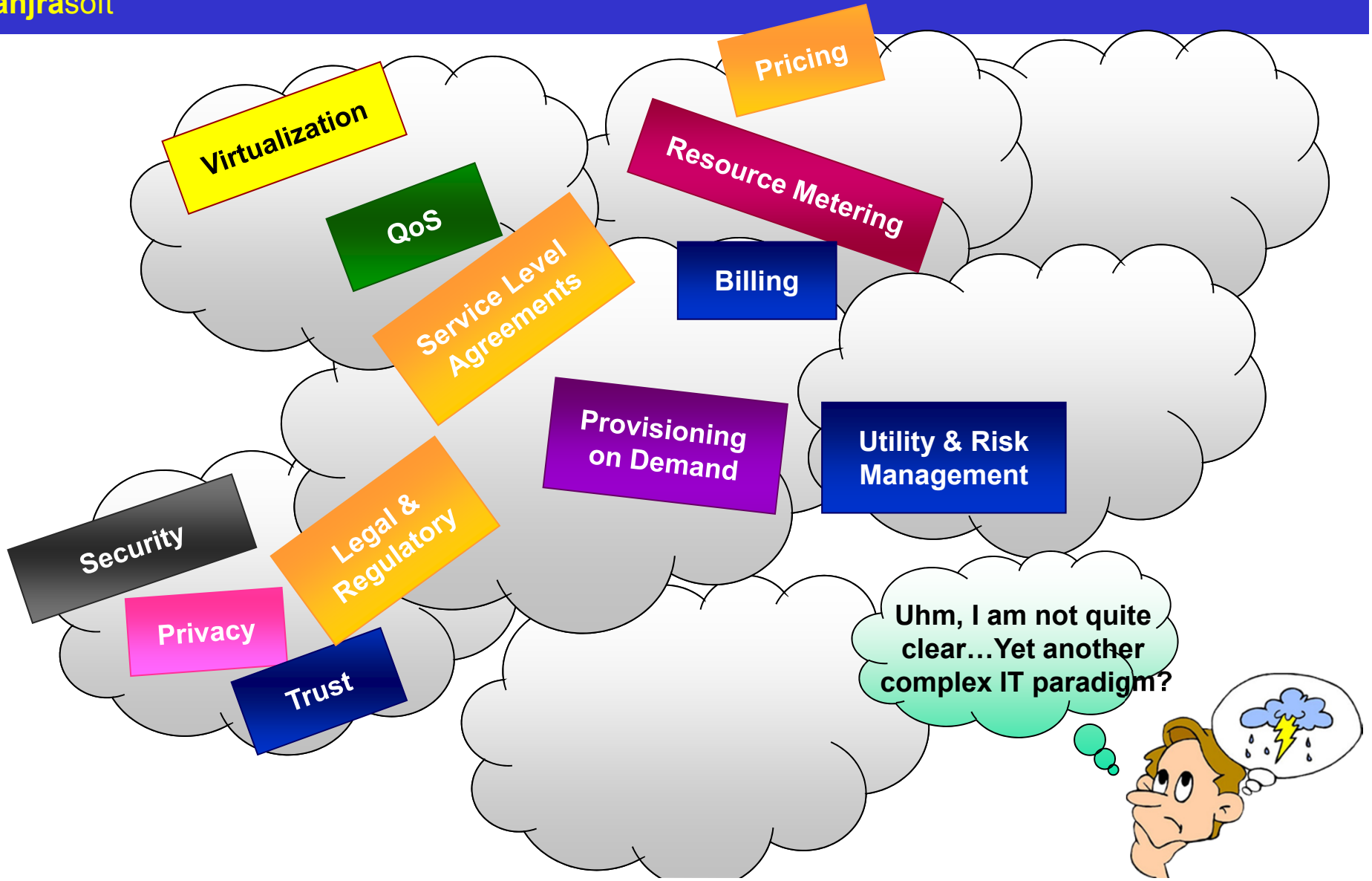

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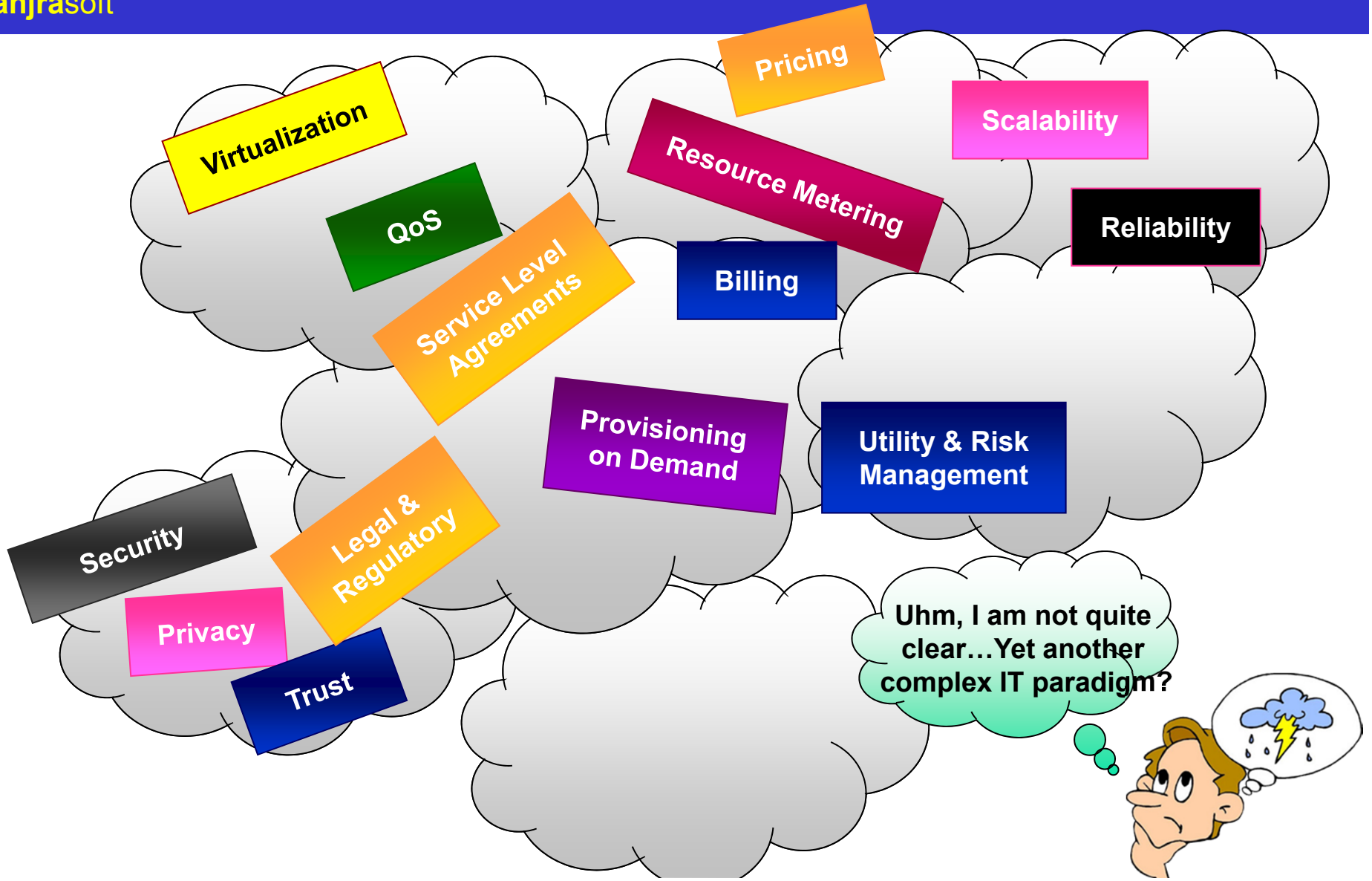

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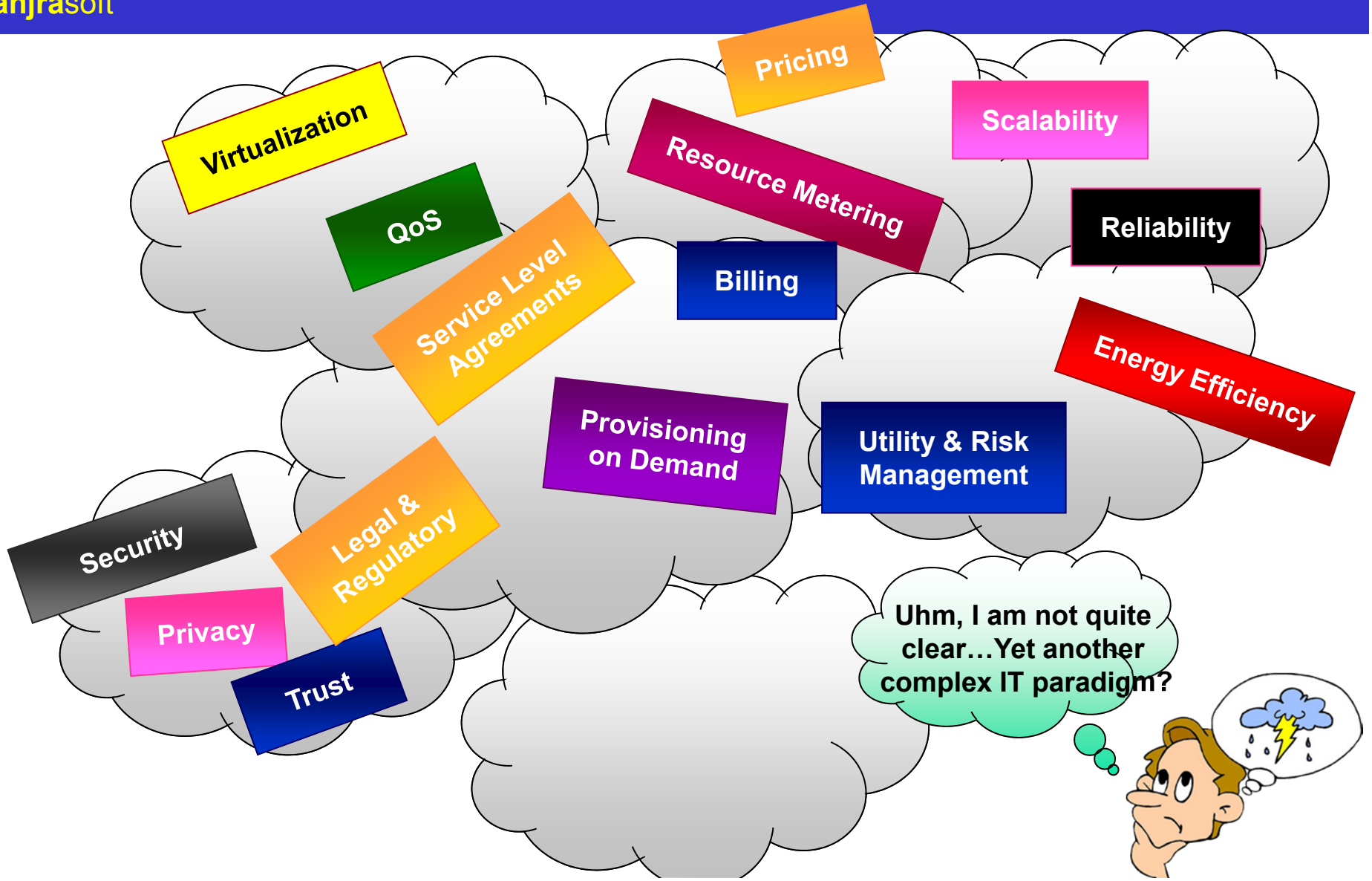

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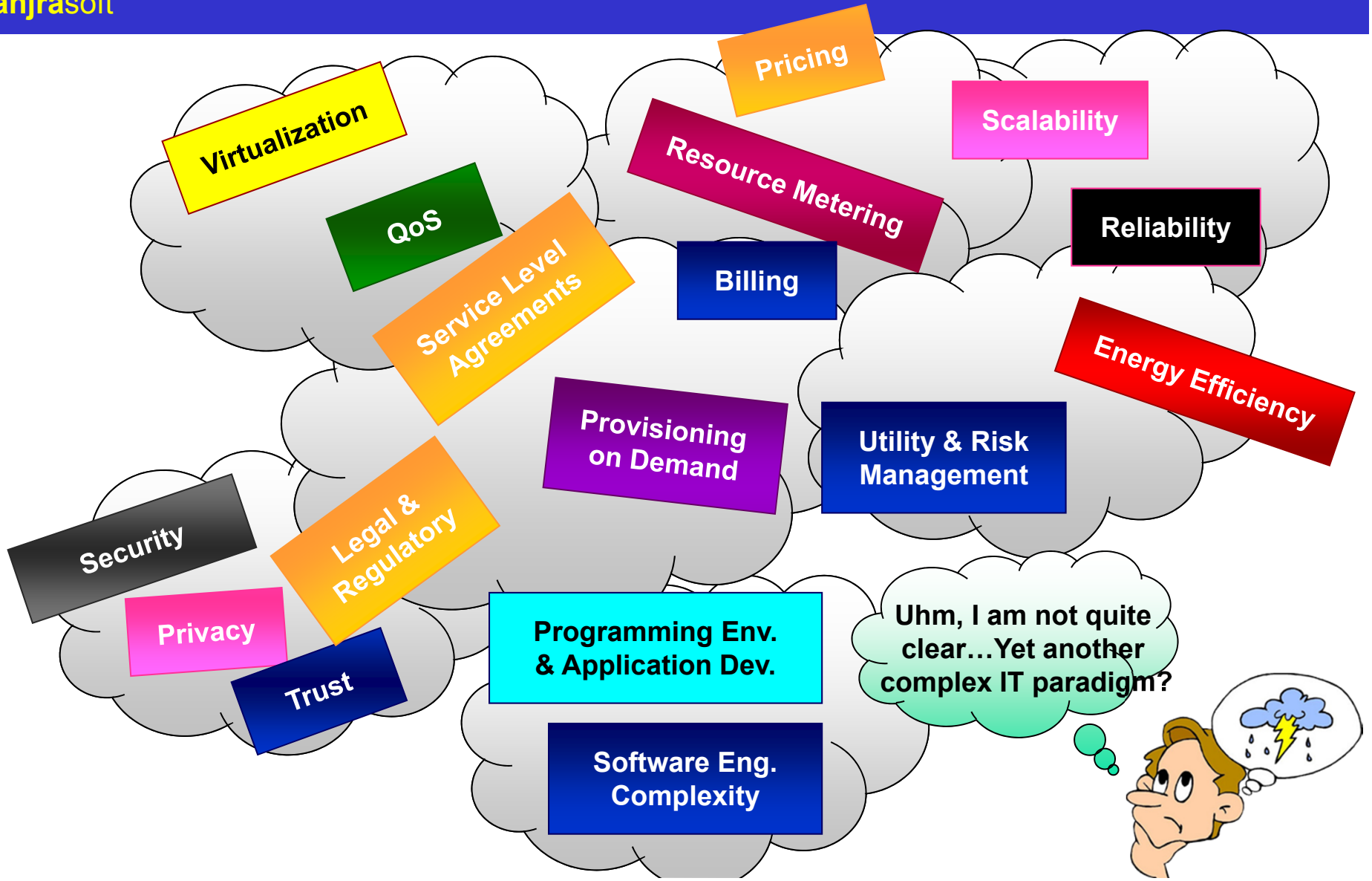
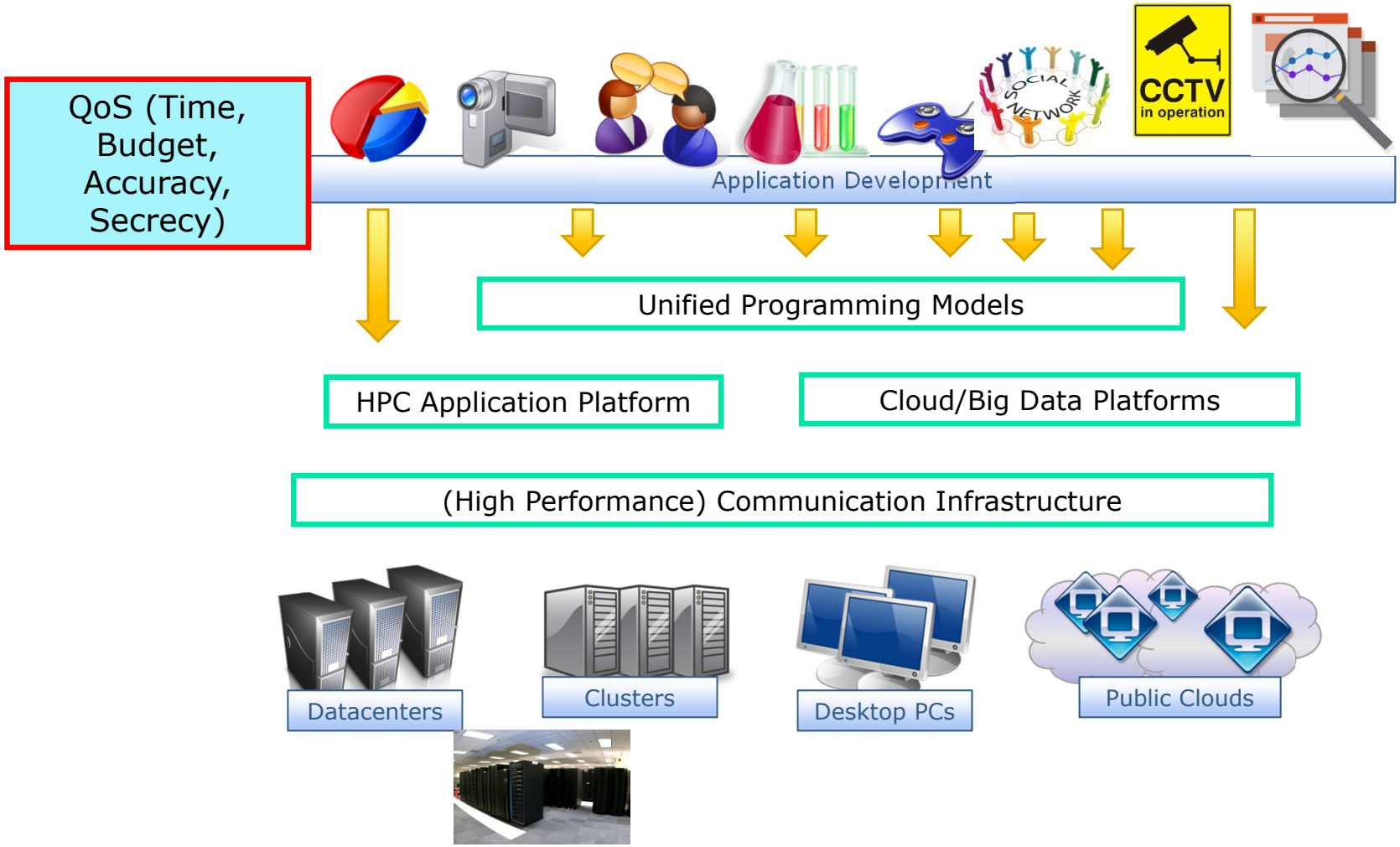
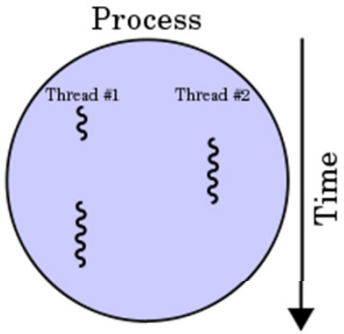


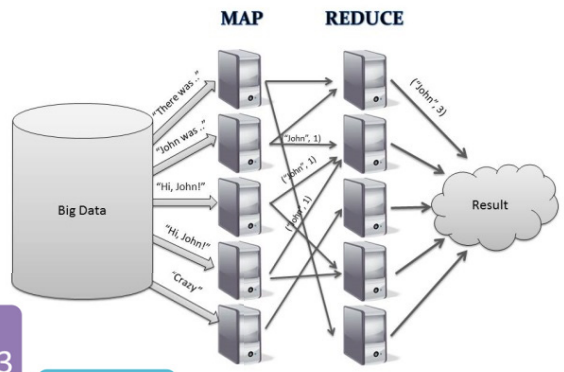
Cloud/Big Data Application Platforms (variety of app models/QoS needs)

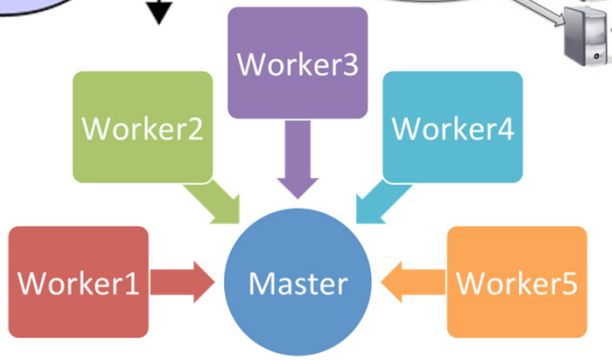


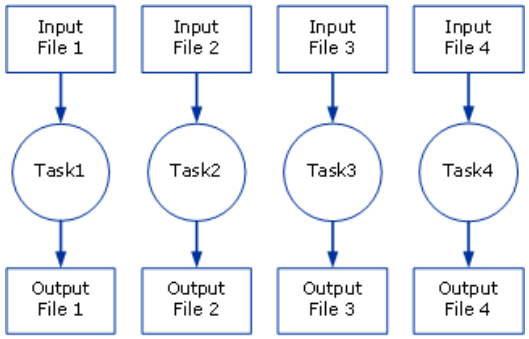
Application Programming Models

- Thread
- Task
- Map Reduce
- Message Passing
  - MPI, …
- Parameter Sweeps
- Workflows
- …

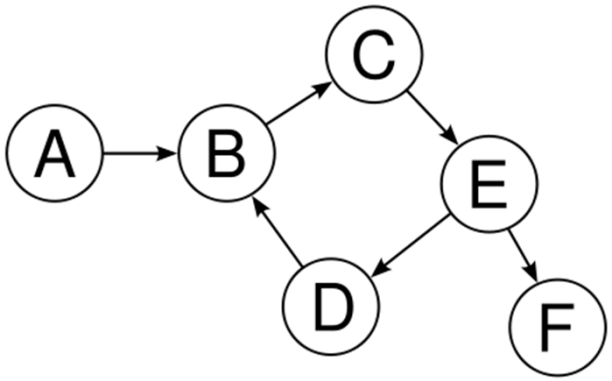








Parametric Sweep



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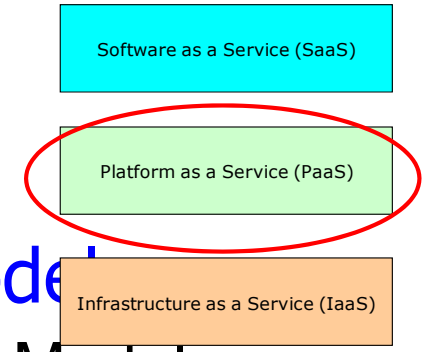

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Aneka: Cloud Application Platform (CAP) for Resource-Intensive/Elastic Apps

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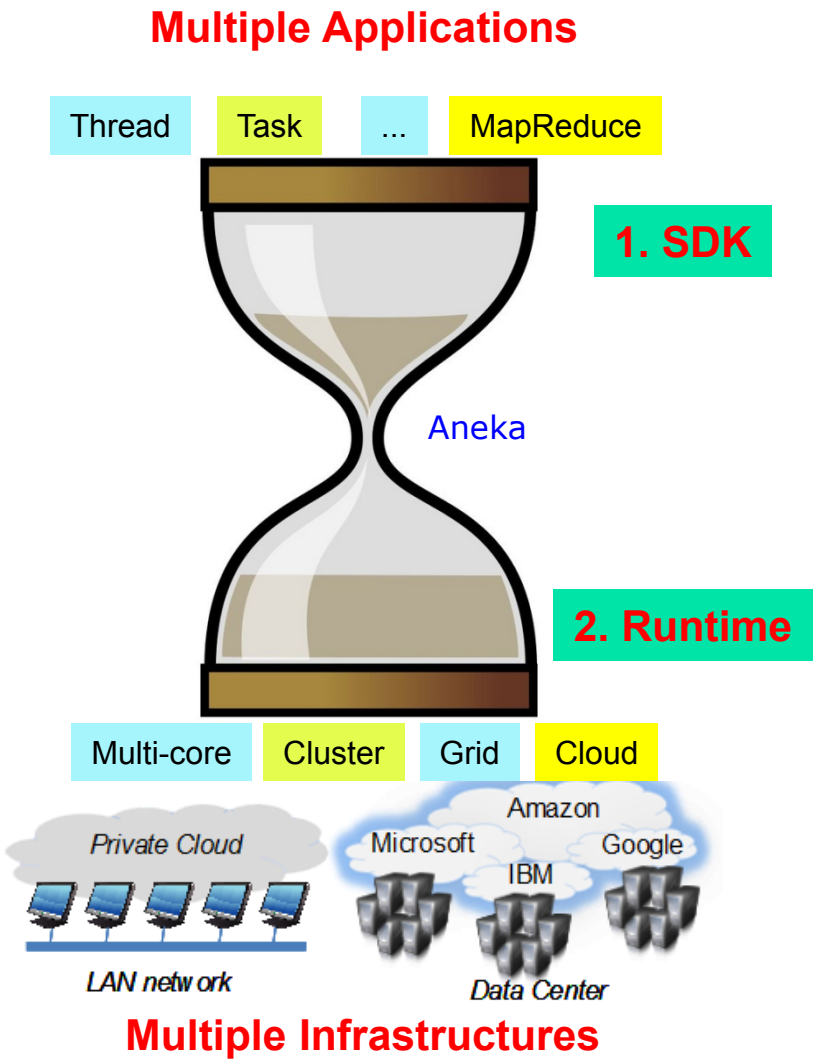
- **World-first** platform supporting multiple Cloud programming models (Task, Thread, MapReduce)
- **SDK (Software Development Kit)** containing APIs for multiple programming models and tools
- **Runtime** Environment for managing application execution on Clouds
- Suitable for
  - Development of Enterprise Cloud Applications
  - Cloud enabling legacy applications
- Portability for Customer Apps:
  - Enterprise ↔ Public Clouds
  - .NET/Win ↔ Mono/Linux



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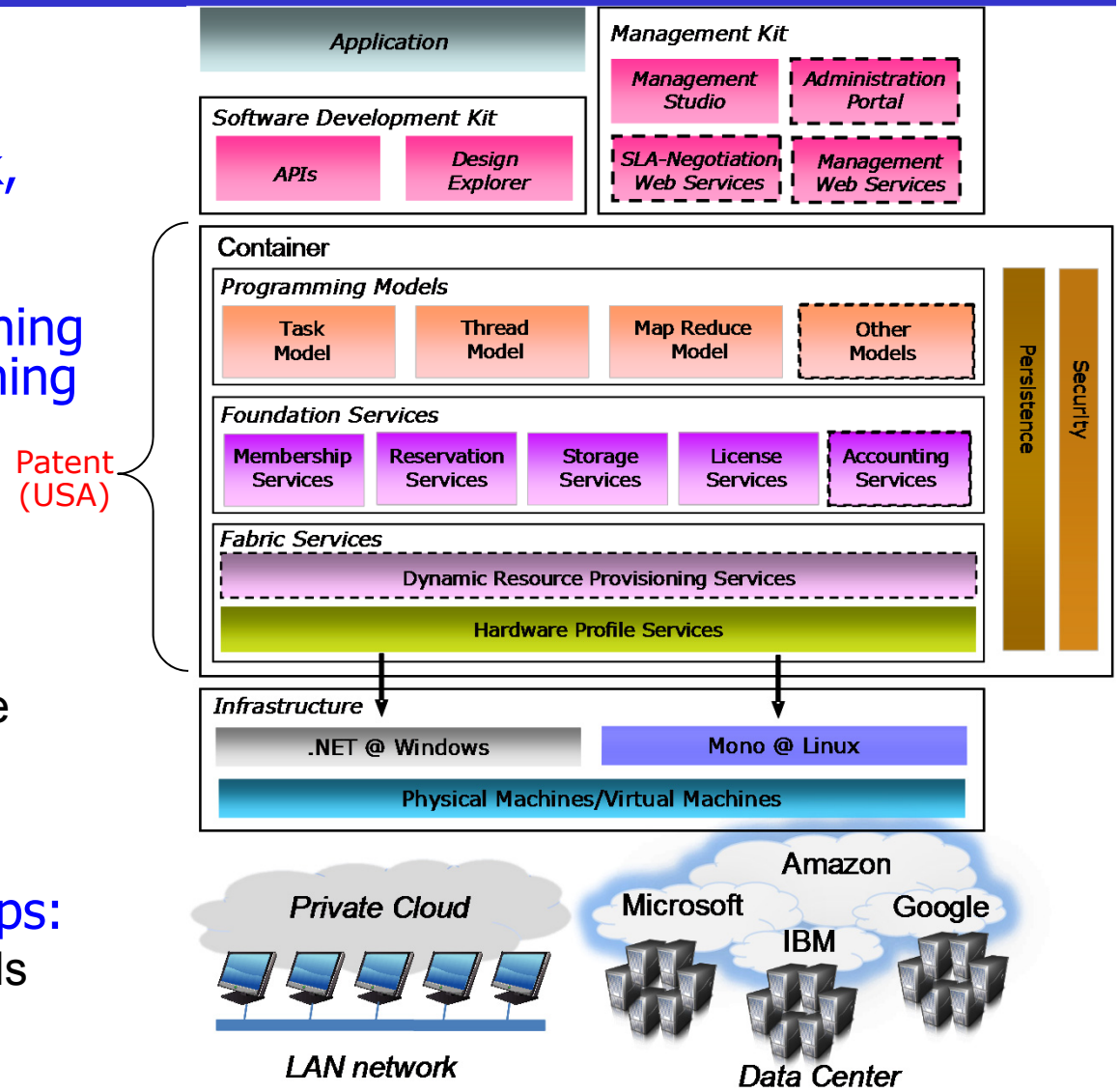

Aneka - Dynamic Management of Application Tasks and Cloud Resources

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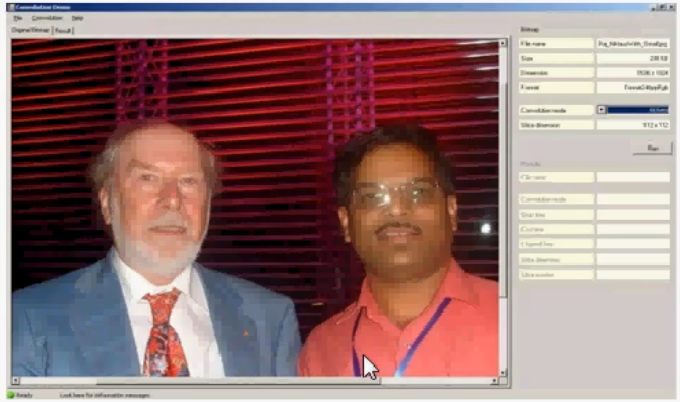
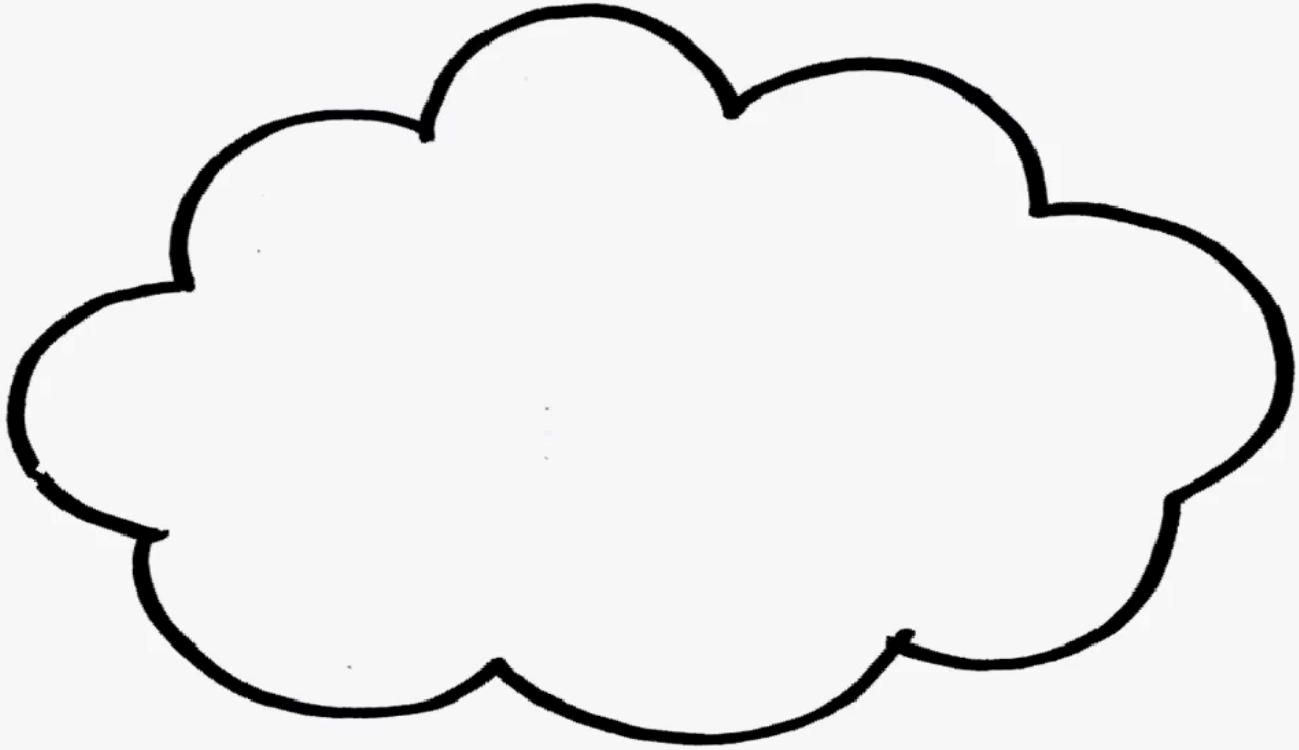
- Application





Deployment Case Studies

CSR
CHINA SOUTH LOCOMOTIVE & ROLLING STOCK CORPORATION LIMITED

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सी डैक CDAC

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UNIVERSITY OF MALAYA
The Leader in Research & Innovation

VEL TECH UNIVERSITY

MAMCE

THAPAR UNIVERSITY

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR
योगः कर्मसु कौशलम्
ENGINEERING COLLEGE ANANTAPUR

(GoFront: A unit of China Southern Railway Group)

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CSR
CHINA SOUTH LOCOMOTIVE & ROLLING STOCK CORPORATION LIMITED

Application: Locomotive design CAD rendering

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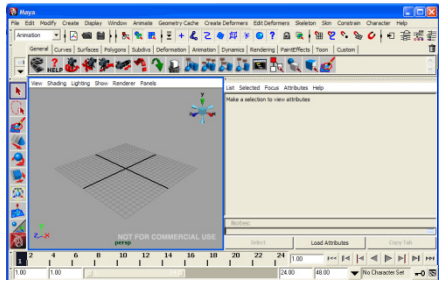

Raw Locomotive Design Files
(Using AutoDesk Maya)

Case 1: Single Server

Using Maya Graphical Mode Directly

4 cores server

(GoFront: A unit of China Southern Railway Group)

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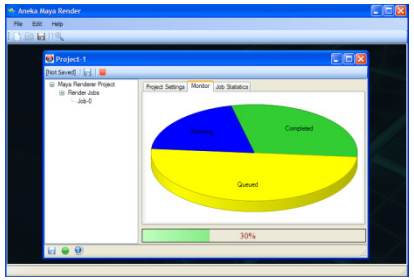
CSR
CHINA SOUTH LOCOMOTIVE & ROLLING STOCK CORPORATION LIMITED

Application: Locomotive design CAD rendering

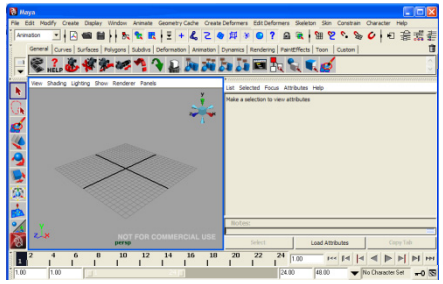
Aneka Maya Renderer



GoFront Private Aneka Cloud

Use private Aneka Cloud

LAN network
(Running Maya Batch Mode on demand)



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Case 2: Aneka Enterprise Cloud

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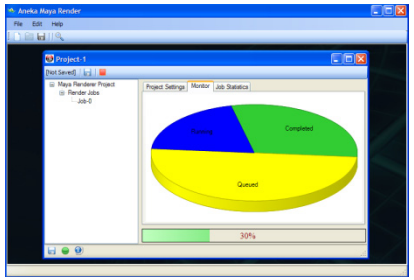

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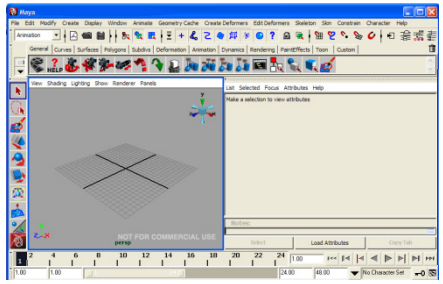

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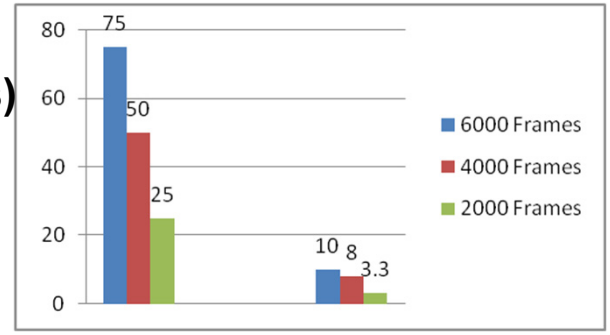
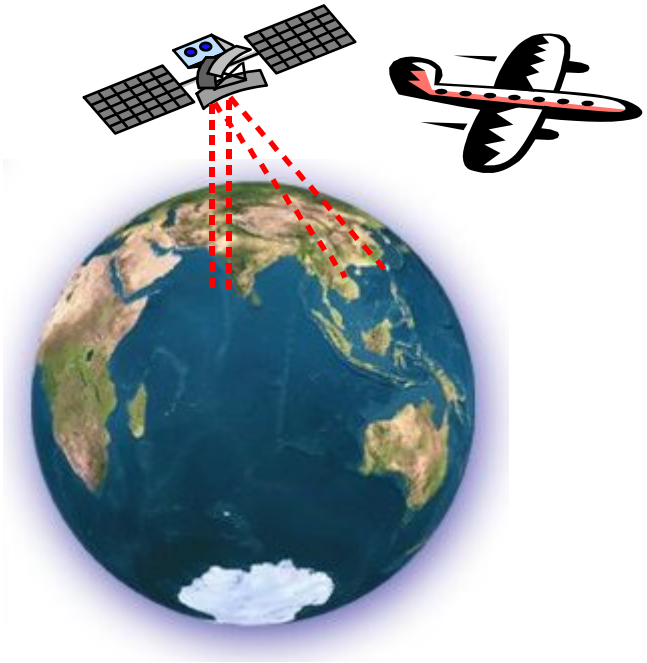
Time (in hrs)



Single Server **Aneka Cloud**

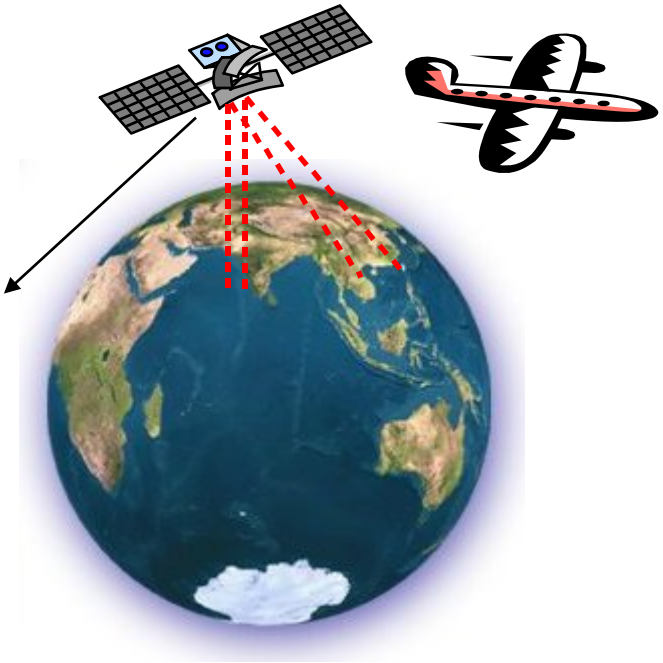
Aneka utilizes idle desktops (**30**) to decrease task time from days to **hours**

Indian Space Research Organization (ISRO) - ADRIN



Receiving station processing

Indian Space Research Organization (ISRO) - ADRIN



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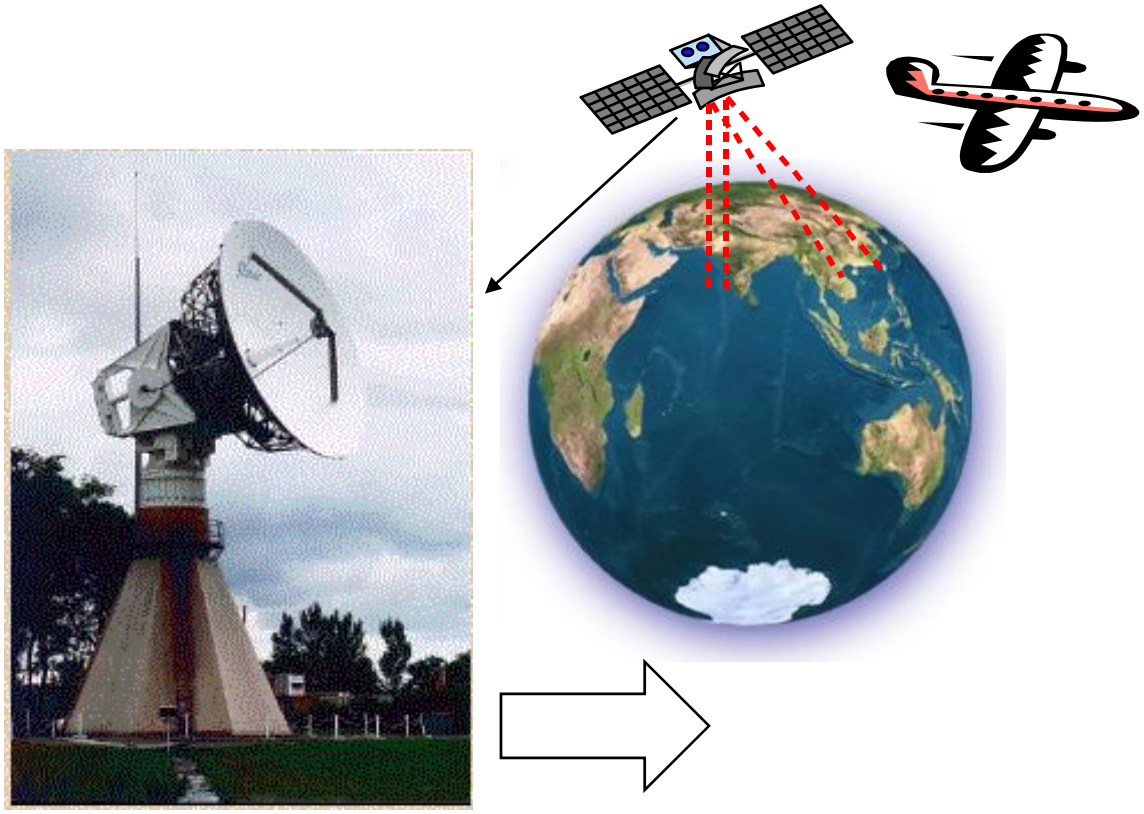

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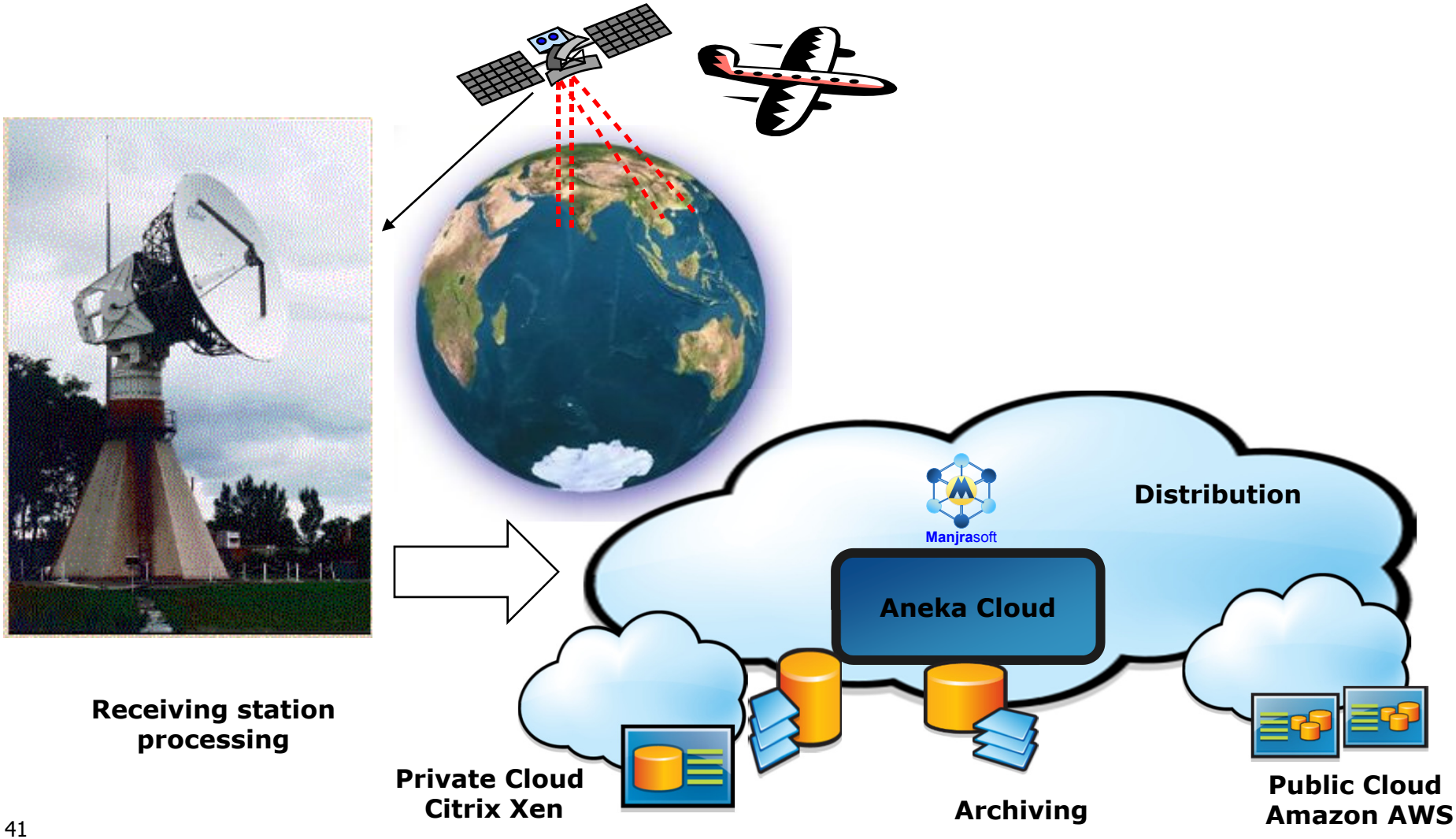

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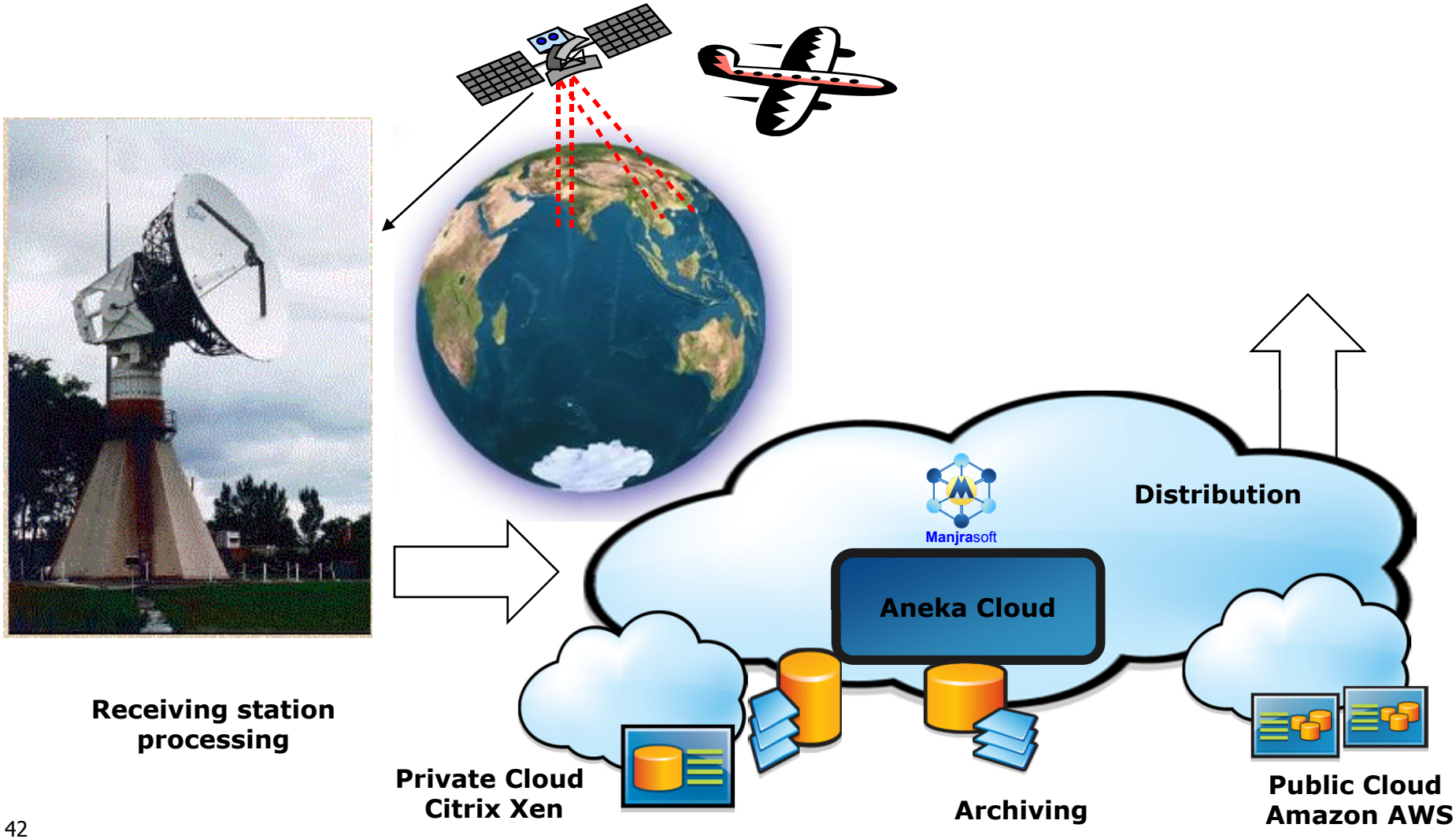

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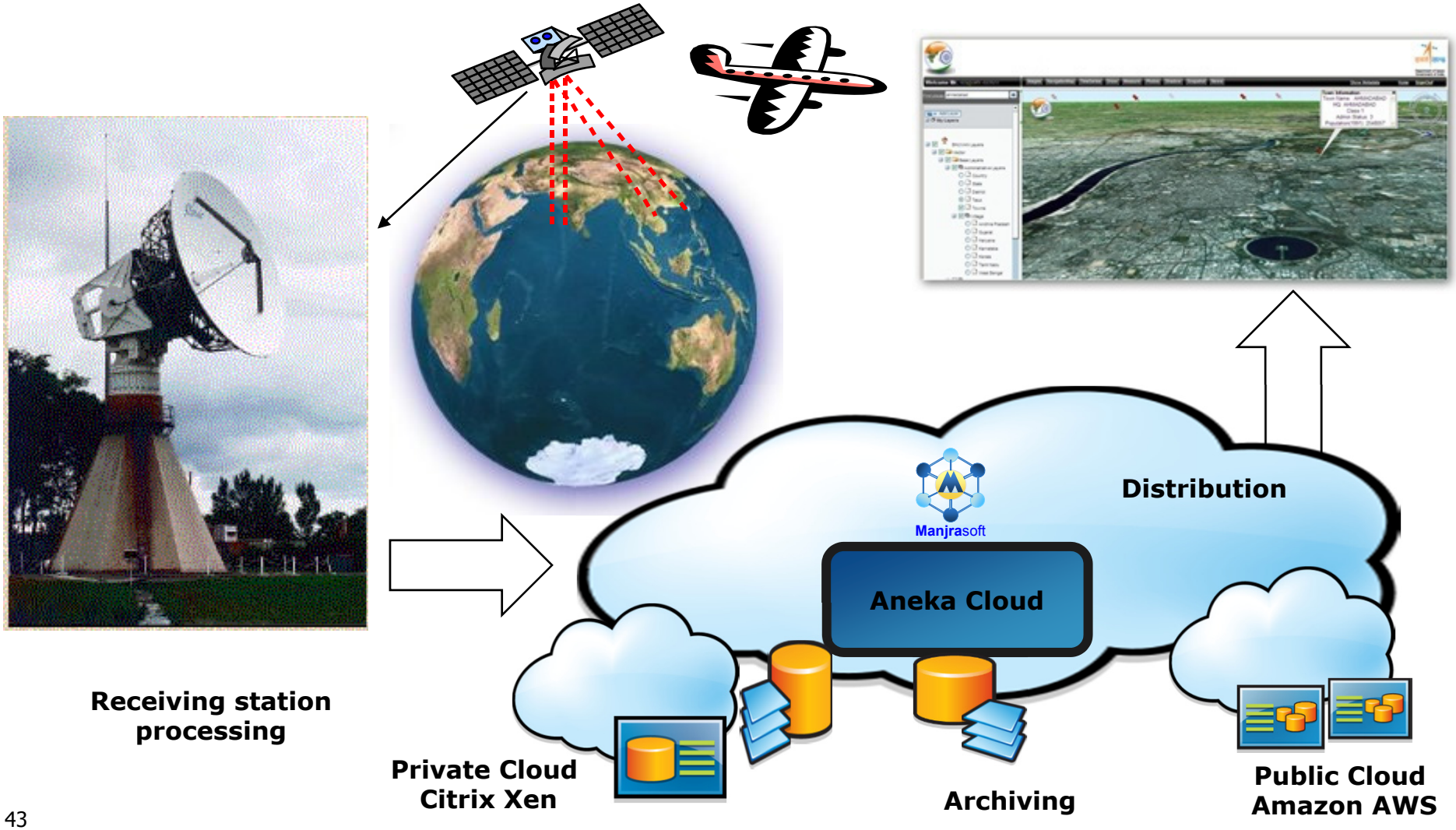

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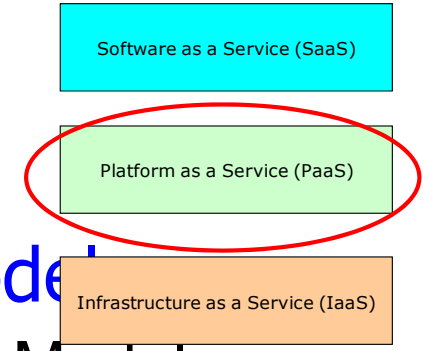

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Cloudbus Workflow Management System

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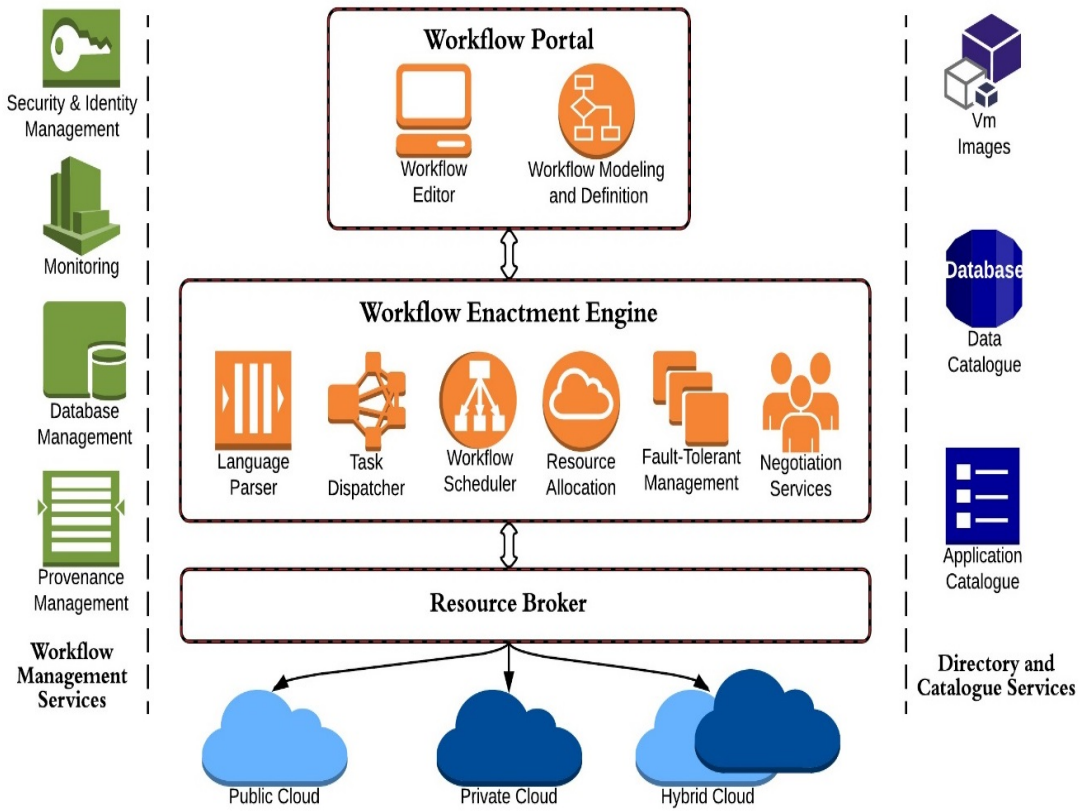
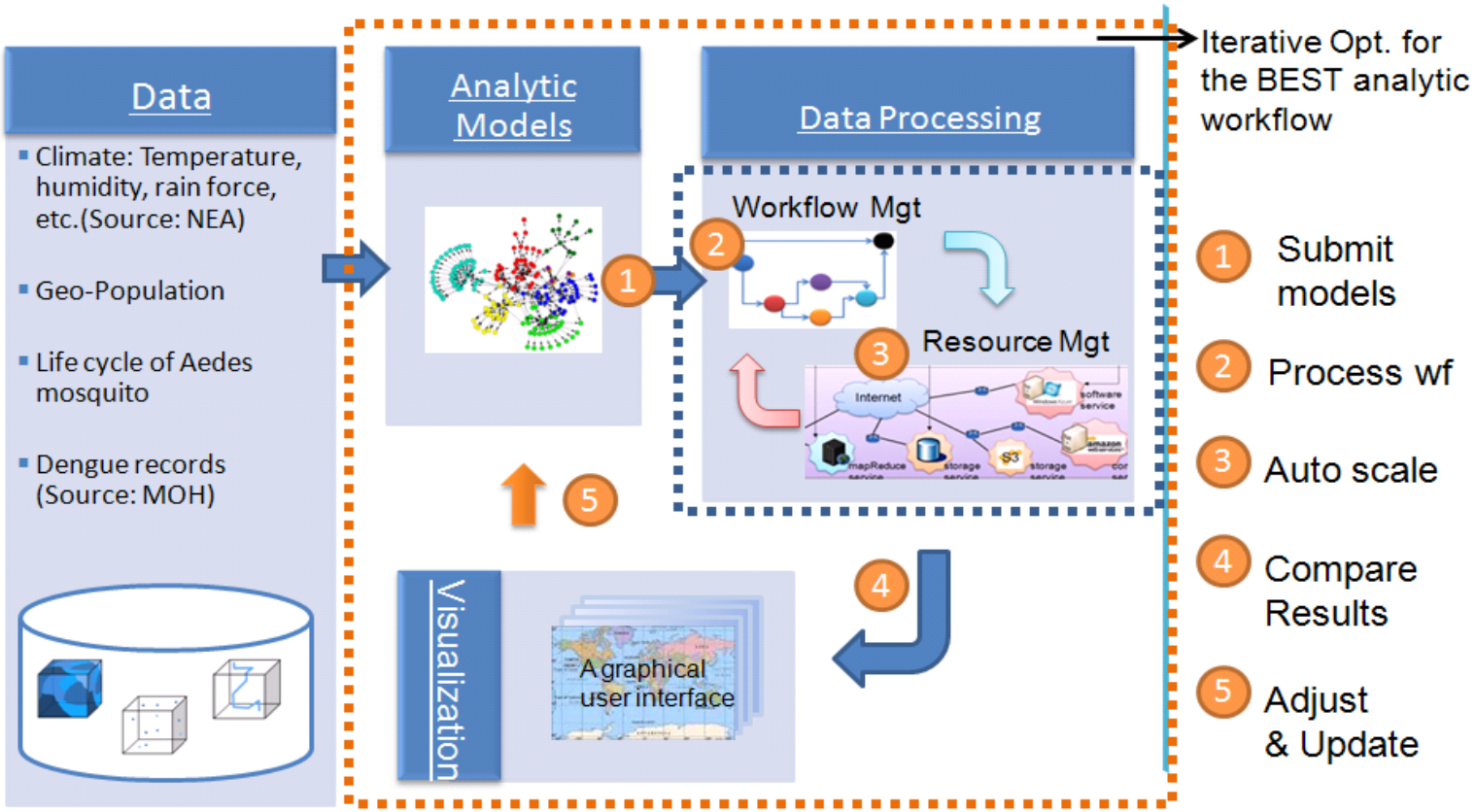
- Workflow Portal
- XML-based Lang.
- I/O Models
  - Many-to-many,
  - many-to-one
  - synchronization
- Workflow Engine
  - App submission handler
  - Scheduler
- Event Service
- Resource Broker
- Applications
  - fMRI, LIGO, Spatial..



A*STAR Singapore use case:
Spatial-temporal data analytics for prediction of dengue fever outbreaks



Multi-Cloud Resource Provisioning Policy

- Create a pool of spot instances
- If resource is available freely, allocate it.
- Else, if budget is there, create an on-demand instance
- If no budget
  - Find a suitable resource that will complete the task in the earliest

47

Running Montage Application on Multiple Clouds

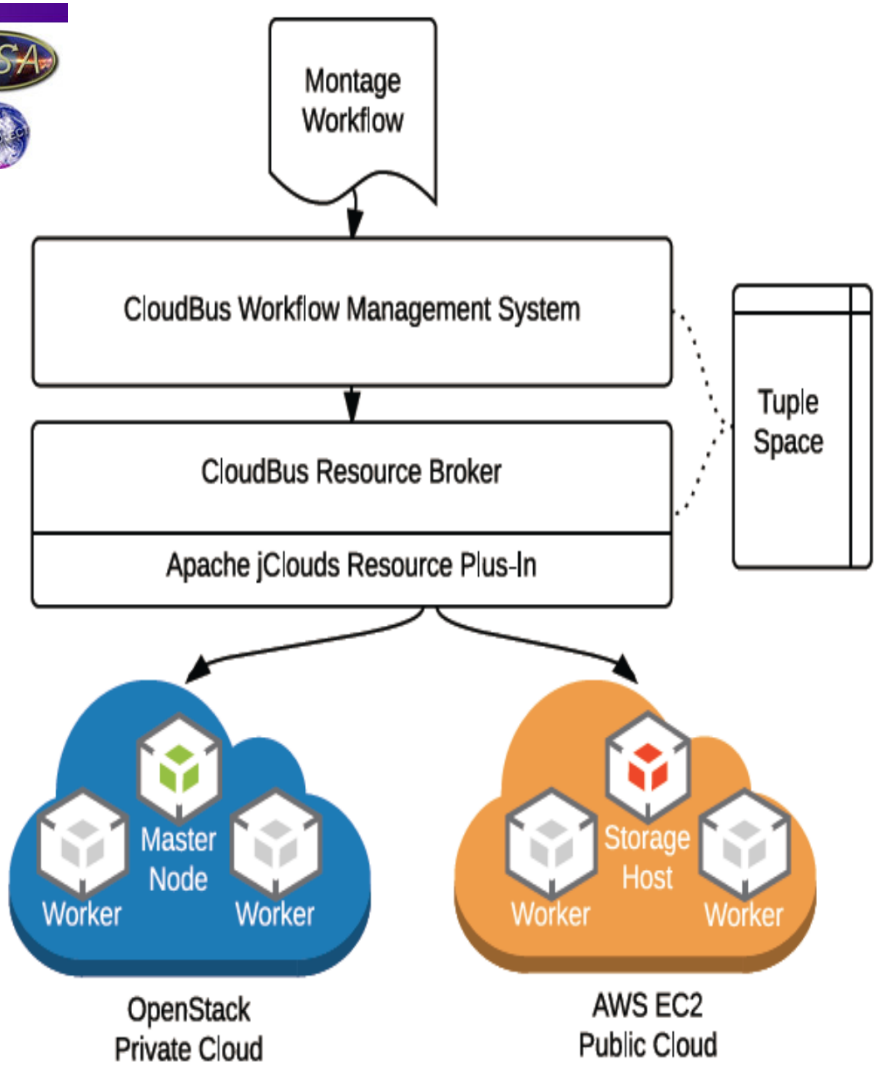
Manjrasoft

Montage

An Astronomical Image Mosaic Engine

NASA Space Act Award Winner 2006

- Montage - Image Mosaic Software for Astronomers
- Montage is a toolkit for assembling Flexible Image Transport System (FITS) images into custom mosaics.
- Montage has been tested by the Montage team on Linux platforms with mosaics built from the 2-Micron All Sky Survey Atlas (full-resolution) images.
- It has been used to generate **mosaics** from data released by Spitzer Space Telescope, Hubble Space Telescope, Infrared Astronomical Satellite, Midcourse Space Experiment , Sloan Digital Sky Survey, and ground-based telescopes such as National Optical Astronomy Observatories 4-m telescope and William Herschel 4-m telescope.
- http://montage.ipac.caltech.edu/



48

Input Data

- **Montage - Image Mosaic Software for Astronomers**
- It is a I/O intensive application, which produces a mosaic of astronomic images.
- We used a montage workflow consisting of 110 tasks, where the number of the tasks indicates the number of images used.

```
maria@montageworker:~/montage_0.5_dag$ cd input
maria@montageworker:~/montage_0.5_dag/input$ ls
2mass-atlas-990502s-j1330068.fits  2mass-atlas-990502s-j1430080.fits
2mass-atlas-990502s-j1330080.fits  2mass-atlas-990502s-j1430092.fits
2mass-atlas-990502s-j1330092.fits  2mass-atlas-990502s-j1430103.fits
2mass-atlas-990502s-j1330103.fits  2mass-atlas-990502s-j1440174.fits
2mass-atlas-990502s-j1340174.fits  2mass-atlas-990502s-j1440186.fits
2mass-atlas-990502s-j1340186.fits  2mass-atlas-990502s-j1440198.fits
2mass-atlas-990502s-j1340198.fits  2mass-atlas-990502s-j1440209.fits
2mass-atlas-990502s-j1340209.fits  2mass-atlas-990502s-j1450068.fits
2mass-atlas-990502s-j1350068.fits  2mass-atlas-990502s-j1450080.fits
2mass-atlas-990502s-j1350080.fits  2mass-atlas-990502s-j1450092.fits
2mass-atlas-990502s-j1350092.fits  2mass-atlas-990502s-j1450103.fits
2mass-atlas-990502s-j1350103.fits  2mass-atlas-990502s-j1460174.fits
2mass-atlas-990502s-j1420174.fits  2mass-atlas-990502s-j1460186.fits
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2mass-atlas-990502s-j1420198.fits  2mass-atlas-990502s-j1460209.fits
2mass-atlas-990502s-j1420209.fits  images.tbl
2mass-atlas-990502s-j1430068.fits
```
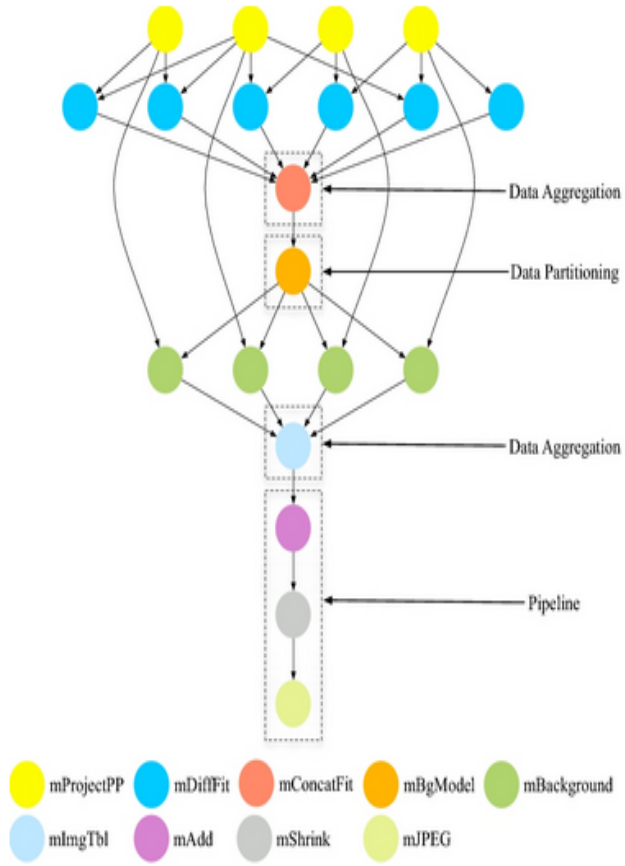
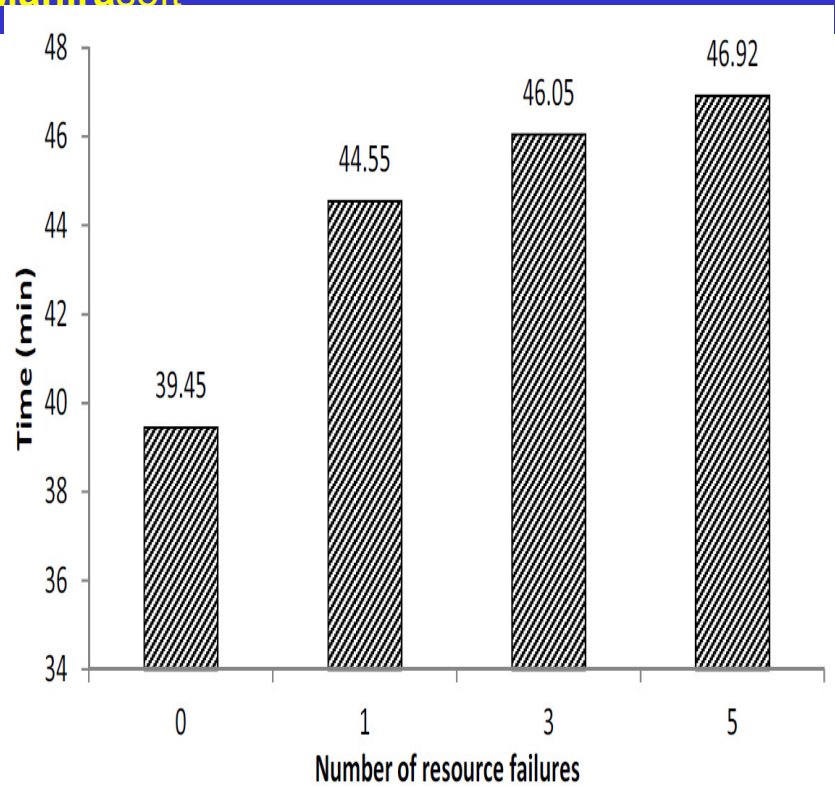
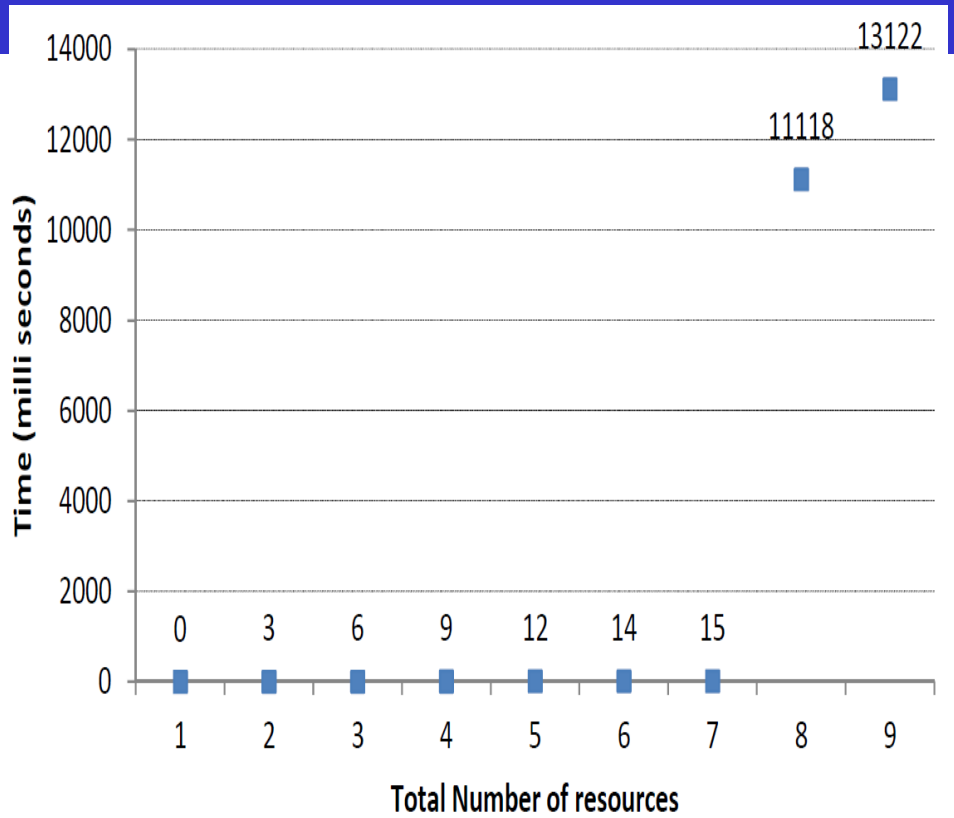

WorkflowGenerator – Pegasus (converted to Cloudbus format)

Workflow Type	Example
Montage The Montage application created by NASA/IPAC stitches together multiple input images to create custom mosaics of the sky.	

https://confluence.pegasus.isi.edu/display/pegasus/WorkflowGenerator

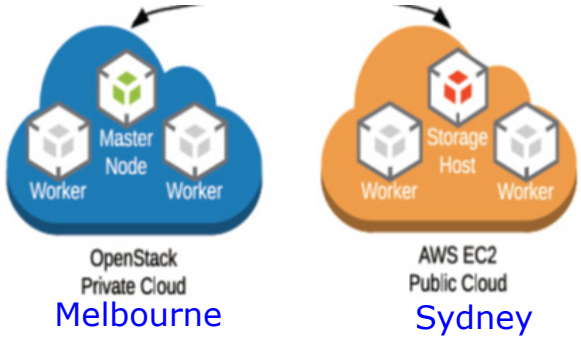
Application Execution



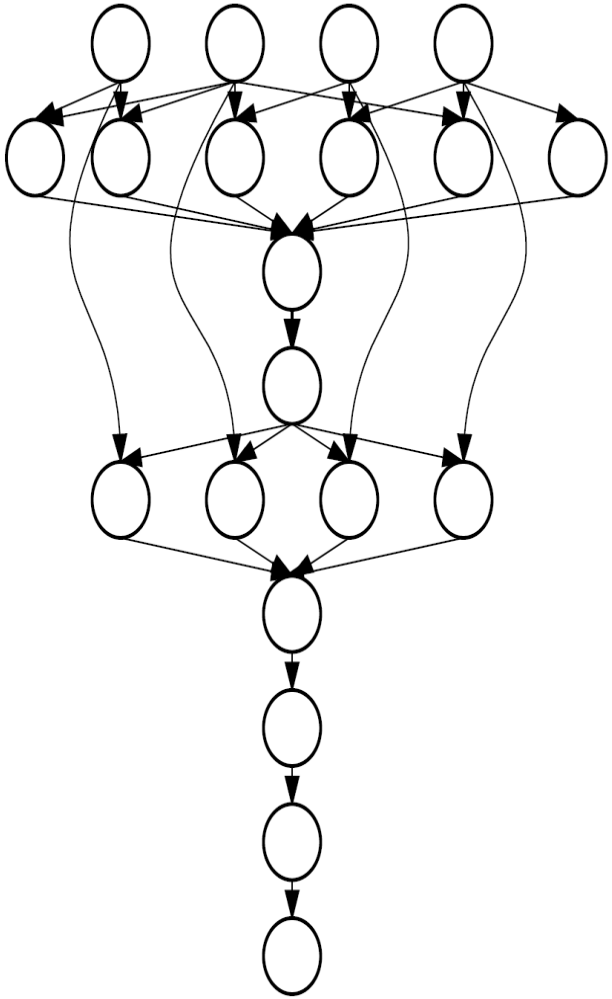


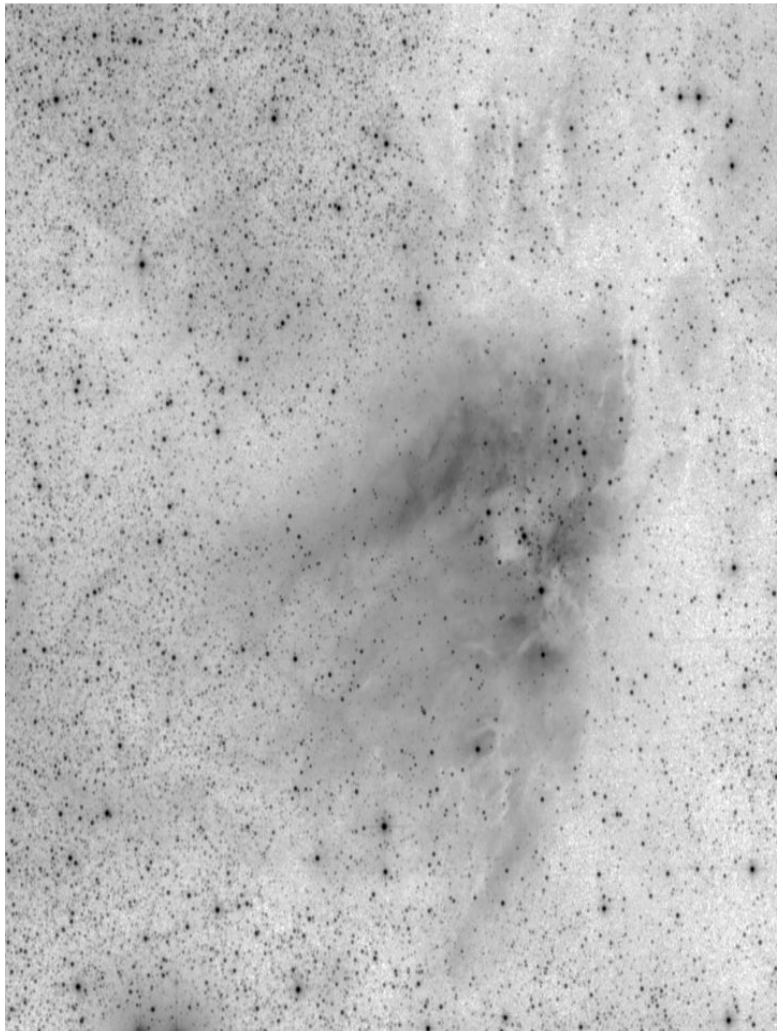
Effect on Makespan under failures:

* Resources: Melb - 4 VMs, AWS: T2 micro – 3 VMs
* 110 tasks (created for .4° output image)
* Deadline set = 55 min



Input and Output (mosaic generated)





52

Outline

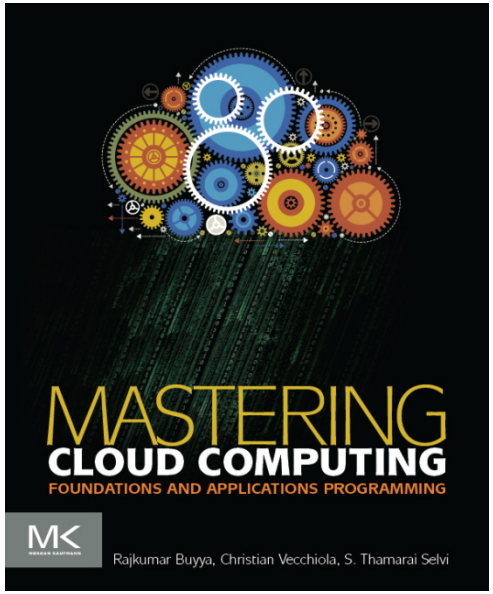
- "Computer Utilities" + Big Data
  - Vision and Promising IT Paradigms
- Cloud Computing and Application Models
  - System View, Applications, Challenges, Models
- Aneka: A Cloud Application Platform
  - .NET-based – multiple/10+ programming languages
  - Models – Task, Thread, MapReduce + Tools
- Cloudbus Workflow Management System
  - Java-based Workflow Engine
  - Apps Demos: fMRI, Spatial, LIGO, Montage
- Summary and Thoughts for Future

Summary

- Several Computing Paradigms have promised to deliver "Computing Utilities" vision:
  - Cloud Computing is the most recent kid in the block promising to turn vision into reality
  - Many exciting business, consumer, and scientific applications
- Aneka is a rapidly emerging as a platform for:
  - Building Clouds and their Apps rapidly – reducing the **cost/time** of application Software Engineering.
  - Applications Demonstrators in engineering, life science, gaming, and business intelligence areas.
- Cloubus Workflow Management Systems
  - Ease composition on workflow apps and their deployment on multiple Clouds (based on Deadline/Budget constraints)
  - Applications Demonstrators in fMRI, Spatial, LIGO, Montage.

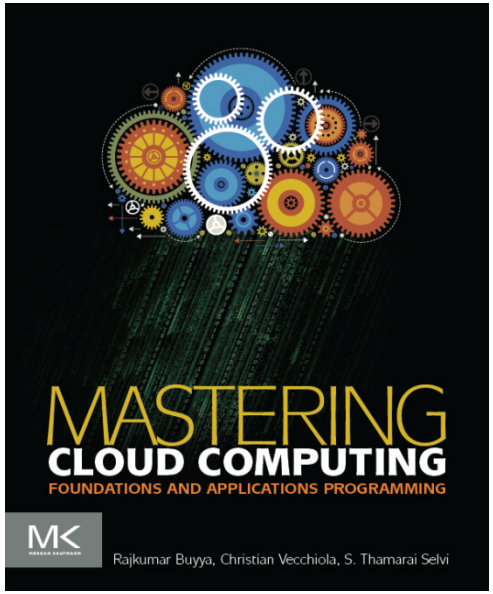
A Reference Book and Journals

A Reference Book and Journals



Morgan Kauffman, USA

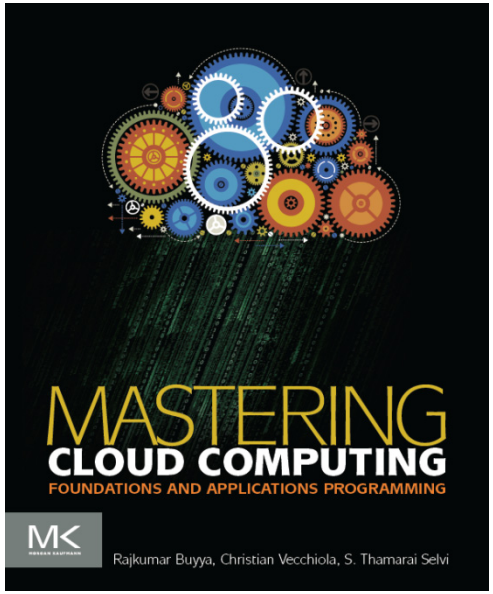
A Reference Book and Journals



Morgan Kauffman, USA

McGraw Hill, India

A Reference Book and Journals

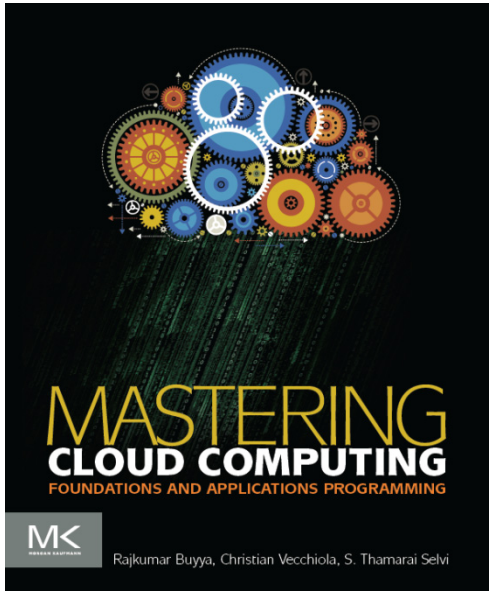


Morgan Kauffman, USA

McGraw Hill, India

China Machine Press, China

A Reference Book and Journals



Morgan Kauffman, USA

McGraw Hill, India

China Machine Press, China

Journal of:
Software: Practice and Experience

IEEE TRANSACTIONS ON
CLOUD COMPUTING
"BREAKTHROUGH RESEARCH AND INNOVATIONS FOR TRANSFORMING CLOUD COMPUTING"

CLOUDS Lab 2015 – a Snap

Thanks for your attention!

- Are there any
  - Questions?
  - Comments/Suggestions

We welcome you to contact:

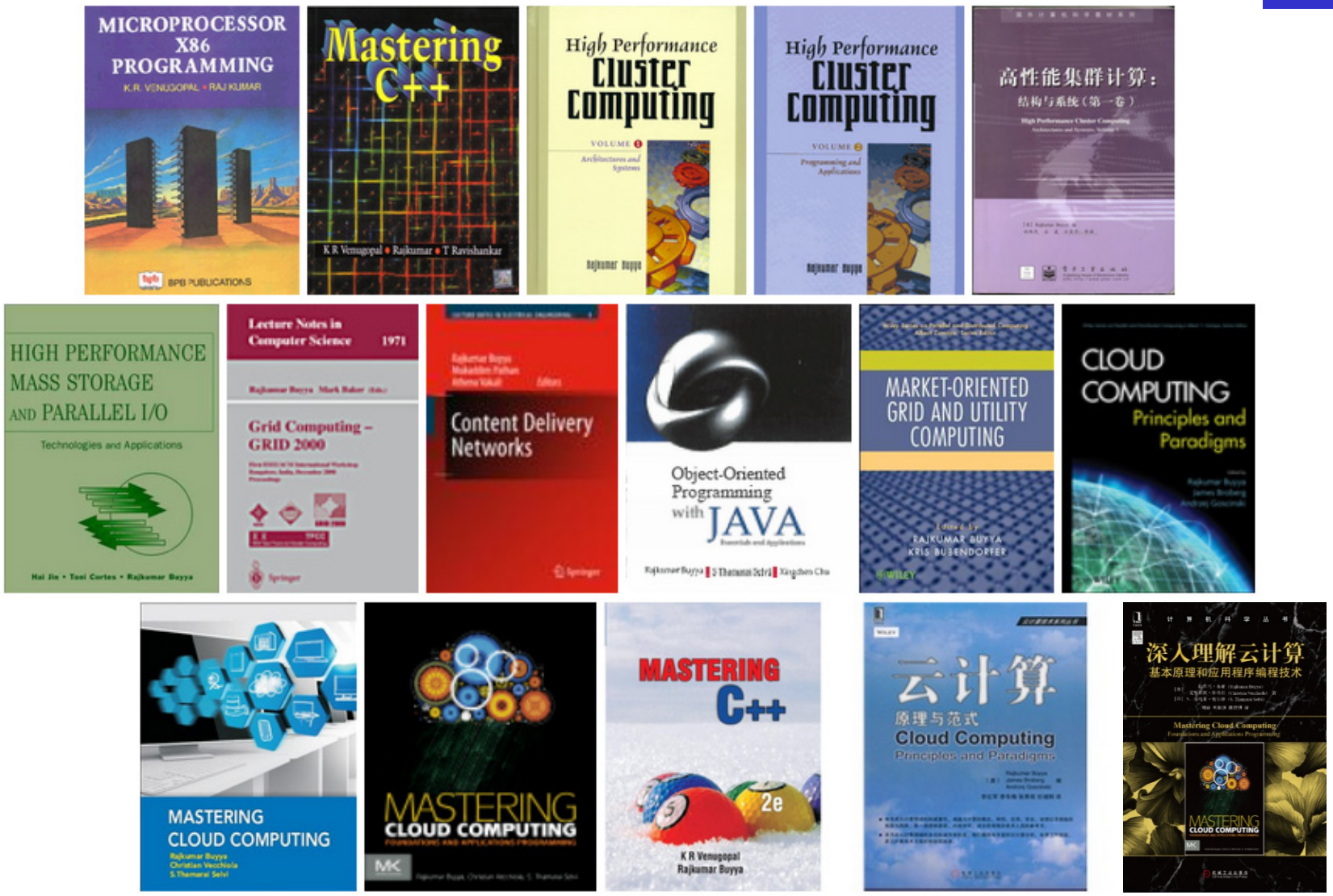
Study/Research with Us | To setup a Cloud Lab

http:/www.cloudbus.org | www.Manjrasoft.com

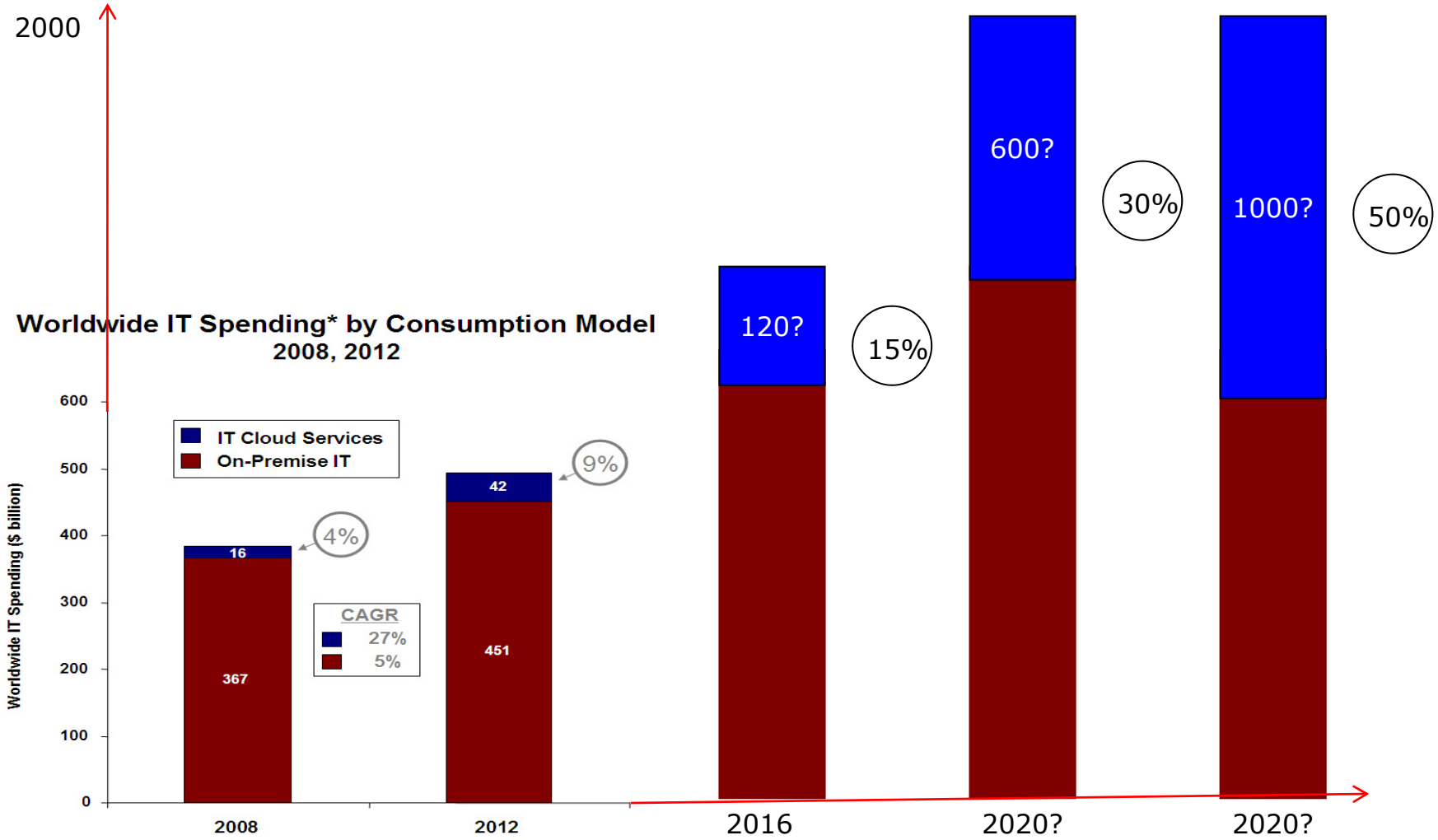
rbuyya@unimelb.edu.au | raj@manjrasoft.com

Manjrasoft

Knowledge Transfer



Cloud Biz Potential: a trillion $ business/year by 2020?



* Includes enterprise IT spending on Business Applications, Systems Infrastructure Software, Application Development & Deployment Software, Servers and Storage

Source: IDC, October 2008

Buyya's Guestimate!

PhD Completion Seminar

Robust and Fault-Tolerant Scheduling for Scientific Workflows in Cloud Computing Environments

Cloud Computing and Distributed Systems (CLOUDS) Laboratory,
Department of Computing and Information Systems
The University of Melbourne, Australia

Deepak Poola Chandrashekar

Supervisor: Prof. Rajkumar Buyya
Co-Supervisor: Prof. Kotagiri Ramamohanarao