Migrating Enterprise Applications To the Cloud

Outline

- Background
- Modeling
- Evaluation
- Conclusion

Background(1)

- Cloud Computing is becoming more and more popular
- Cloud Computing reduce the cost of IT infrastructures
- Users purchase On-Demand Resources

Background(2)

- Characteristics of enterprise applications
  - Typically, three functional tiers:
    - A front-end(FE) tier (e.g. web server)
    - A business-logic(BL) tier
    - A back-end(BE) tier (e.g. databases)
  - Users
    - Internal or external users
  - Security policy
    - Access Control Lists(ACLs) are widely used to ensure security

Background(3)

- In a recent survey of data center managers, over 72% of respondents were considering or using public cloud computing.

- What are concerns of data center managers ?
  - Performance
    - Little is known about the performance of app in the cloud
  - Benefits of Cloud
    - Compared with their own local servers, the fee of cloud is cheaper ?
  - Privacy & Security
    - Some sensitive data cannot be migrated to the cloud (e.g. information of credit card)

Background(4)

- Thus, Hybrid cloud architecture is an option
- Issues in migrating enterprise
  - Migrating the entire application to the cloud will result in higher response time to internal users.
  - From Privacy perspective, enterprises may not move sensitive data to cloud

How to solve this problem?

- There are two respects:
  - **Migration of components ***
    - Decide which one will be moved to the cloud
  - Migration of ACL
    - To guarantee that the security policies will not be changed

Modeling(1)

The application structure can be described as a graph:

$$G = (V, E).\ \text{Let}\ V = \{\mathrm{C}_i\}_{i=1}^{m} \cup \{I, O\}$$

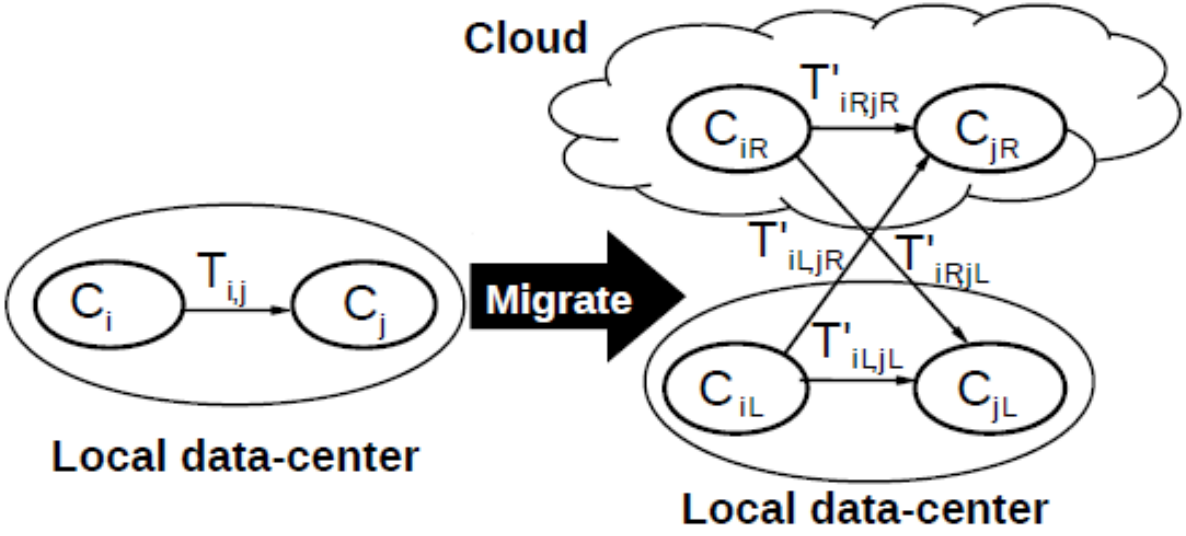
Each *Ci* is modeled as consisting of *Ni* servers. So the problem is decide how many servers will be migrated to the cloud for each *Ci*

And the goal is to determine a migration strategy M:

$$\begin{aligned} \max \quad & \mathrm{Benefits}(M) - \mathrm{InternetCosts}(M) \\ \text{subject to} \quad & \text{Policy Constraints } \mathbf{P} \\ & \text{Constraints on } \mathrm{DelayIncrease}(M) \\ & \text{Flow Balance Equations} \end{aligned}$$

Modeling(2)

- Flow balance equations



Modeling(3)

- Flexible routing approach:

$f_i = \frac{n_i}{N_i}$ (f_i denotes the fraction of servers to migrate).

$$T_{i,j}(1 - f_i) = T'_{iL,jL} + T'_{iL,jR}$$
$$T_{i,j}(f_i) = T'_{iR,jL} + T'_{iR,jR}$$
$$T_{i,j}(1 - f_j) = T'_{iL,jL} + T'_{iR,jL}$$
$$T_{i,j}(f_j) = T'_{iL,jR} + T'_{iR,jR}$$
$$T'_{iL,jL}, T'_{iL,jR}, T'_{iR,jL}, T'_{iR,jR} \geq 0$$

- Independent routing approach:

Let $f(i, A) = \frac{n_i}{N_i}$ if $A = R$ and $\frac{N_i - n_i}{N_i}$ if $A = L$.

$$T'_{iA,jB} = T_{i,j} f(i, A) f(j, B)$$

Modeling(4)

- Internet communication costs:

$$\mathrm{Cost}_{L,I}(\mathrm{Tr}'_{L,I} - \mathrm{Tr}_{L,I}) + \mathrm{Cost}_{R,I}\,\mathrm{Tr}'_{R,I}$$

where $\mathrm{Cost}_{L,I}$ and $\mathrm{Cost}_{R,I}$ are respectively the per-unit Internet communication cost of traffic from the local and cloud data centers, $\mathrm{Tr}'_{L,I}$ ($\mathrm{Tr}_{L,I}$) and $\mathrm{Tr}'_{R,I}$ respectively denote the traffic from the local data center and the cloud to the Internet after (before) migration.

Modeling(5)

- Mean delay of transactions:

  The delay for each request before(after) migration:

$$E[D] = \sum_{i \in V} E\left[\chi_i D_i\right] + \sum_{e=(i,j) \in E} \left(\frac{T_{i,j}}{t} E\left[D_e\right] \right)$$

$$E[D'] = \sum_{i \in V'} E\left[\chi'_i D'_i\right] + \sum_{e=(i,j) \in E'} \left(\frac{T'_{i,j}}{t} E\left[D'_e\right] \right)$$

  The increase in mean delay:

$$\sum_{e=(i,j) \in E'} \left(\frac{T'_{ij}}{t} E\left[D'_e\right] \right) - \sum_{e=(i,j) \in E} \left(\frac{T_{ij}}{t} E\left[D_e\right] \right).$$

Modeling(6)

- There are two kinds of components:
  - 1. compute-intensive
  - 2. storage-intensive

- So the benefits is:

$$B_c M_c + B_s M_s.$$

Modeling(7)

- Solve the optimization problem
  - If the flexible routing approach and constraints of mean delay are used, the problem becomes an integer programming problem. Tools like CPLEX can solve it.
  - If the independent routing approach or constraints of variance is considered, the problem becomes a non-linear problem. Tools like BARON can do it.

Evaluation(1)

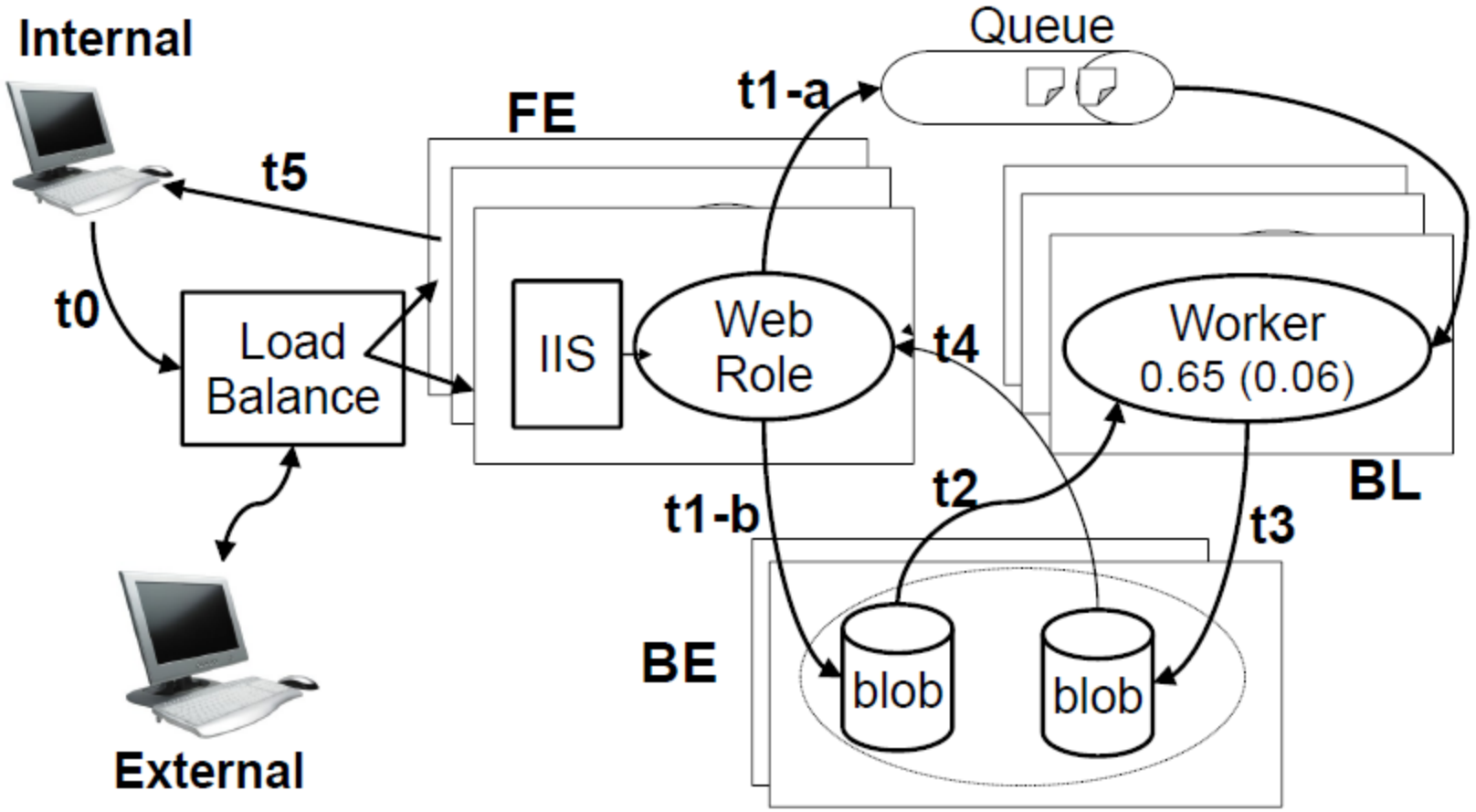


Figure 8: Data flow of thumbnail application.

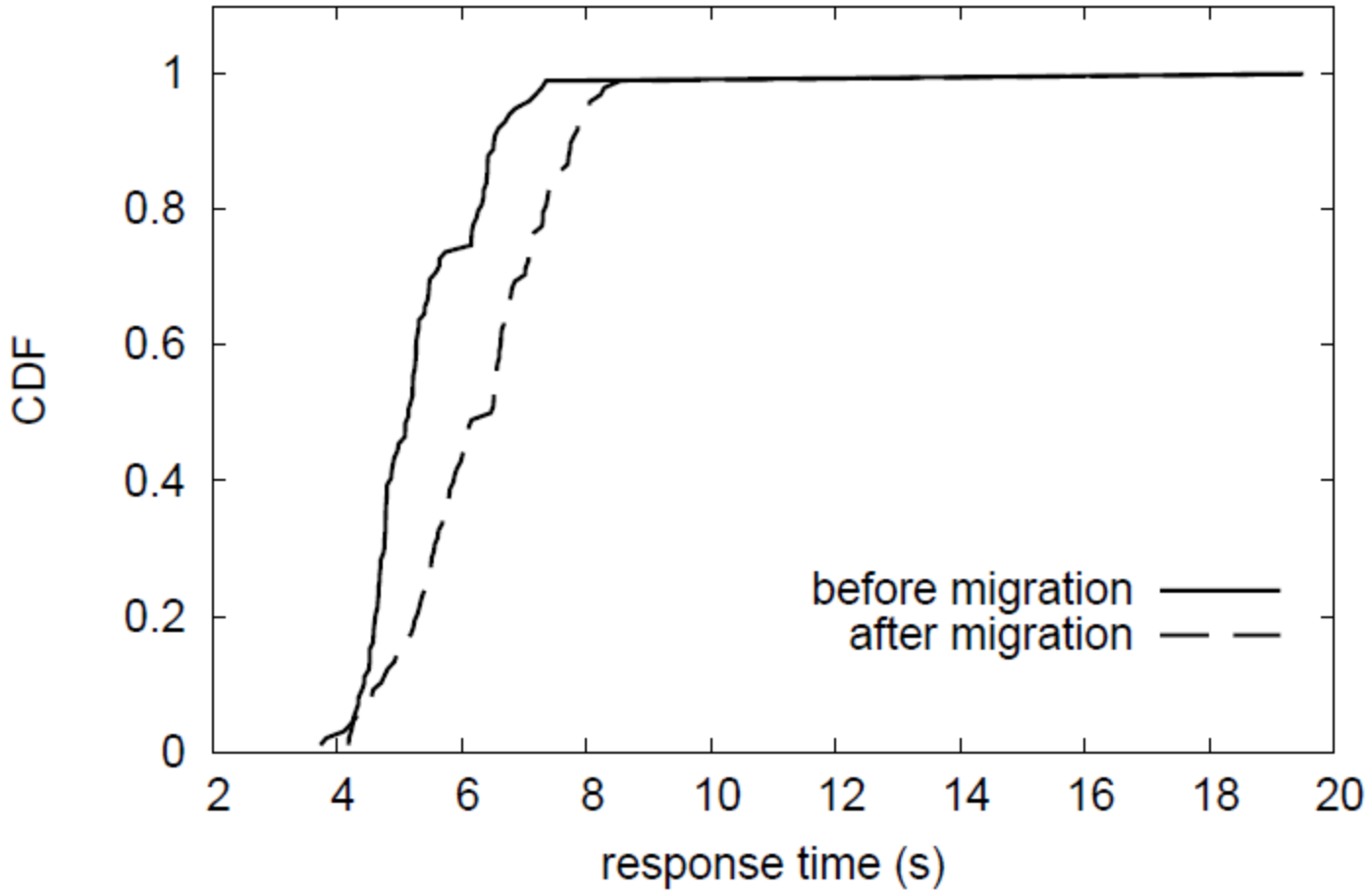
Evaluation(2)

- Cloud
  - Azure
- Deriving model parameters
  - Measure the mean of delay, service time, transfer time
- Migration benefits and communication costs:
  - Assume migrating servers to the cloud can reduce costs by a factor 7 for compute-class servers, and 5 for storage-class servers.

Evaluation(3)

D \ V	125%	150%	175%	no bound
105%	1/1/1, $20024	1/1/1, $20024	1/1/1, $20024	1/1/1, $20024
110%	1/1/1, $20024	1/3/2, $36367	1/2/2, $36836	2/2/2, $38413
150%	1/1/1, $20024	1/3/3, $53647	1/3/3, $53647	1/3/3, $53647
200%	1/1/1, $20024	1/3/3, $53647	2/3/3, $55224	3/3/3, $56801

Evaluation(4)



Evaluation(5)

- Another example:

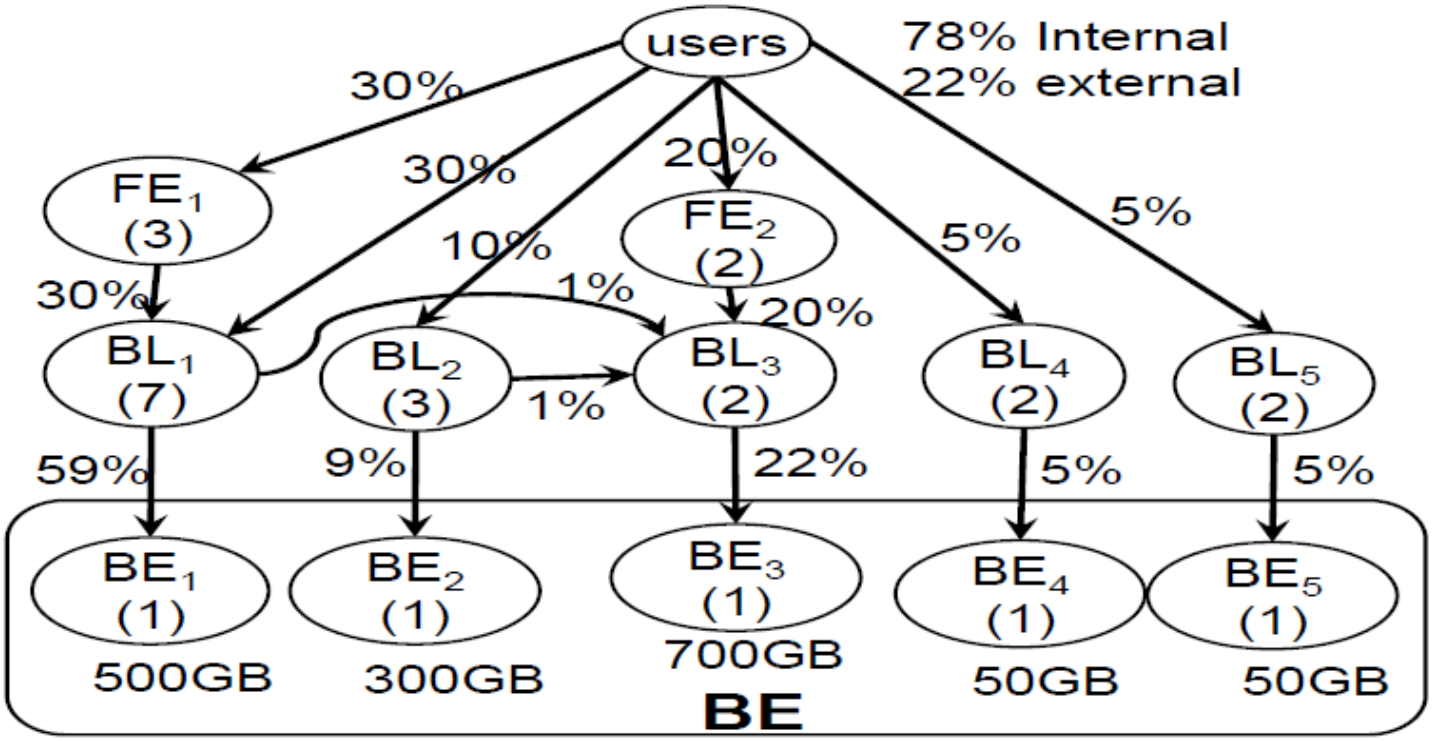


Figure 10: The ERP application in a large university.

Evaluation(6)

Delay Bound	Yearly Savings	Recommended Components to Migrate		
		FE	BL	BE
115% w/ policy	\$14,102	$FE_1(1)$	$BL_1(2)$, BL_2, BL_4, BL_5	—
115%	\$37,769	$FE_1(1)$, FE_2	$BL_1(1)$, BL_2, BL_3, BL_4, BL_5	BE_2, BE_3, BE_4, BE_5
110%	\$27,789	FE_2	$BL_2(1)$, BL_3, BL_5	BE_2, BE_3, BE_5
120%	\$43,592	$FE_1(1)$, FE_2	$BL_1(2)$, BL_2, BL_3, BL_5	BE_1, BE_2, BE_3, BE_5
130%	\$57,763	migrate all components in full		

Table 2: Recommendations of the planned approach for ERP application.

Conclusion(1)

- The potential benefits of hybrid cloud deployments of enterprise applications;
- Constraints of Delay & Security Policy will limit the benefits of Migration.
- This paper does not consider the cost of migration.

Reference

[1] M.Hajjat, X.Sun, Y.-W.E.Sung, D.Maltz, S.Rao, K, Sripanidkulchai, and M. Tawarmalani . Cloudward Bound: Planning for beneficial Migration of Enterprise Applications to the Cloud. In Proc SIGCOMM, 2010

- Thanks!