Software System Design-Architecture
Assignment 3
C4 System Architecture Design

4 people

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1 Deploying ADD method in C4 Design

1.1 Important Non-functional Requirements

The important non-functional requirements we identified are listed bellow:

- Availability
- Performance
- Modification
- Scalability
- Interoperability
- Consistancy
- Integrity
- Usability

The constrains we identified are listed bellow:

- No persistent data caching on the agent workstations to limit the implications of local failures.
- No DBs at office locations.
- No administrators at local offices.
- No maintenance down-time.
- The middle layer server cluster tuned for performance.
- The back end tuned for DB performance.
- Well engineered operations architecture.
- High availability cannot be achieved by utilizing fault-tolerant hardware (this option is not economically viable).

The scenarios are listed as following:

Portion of Scenario	Possible Values
Source	End users and internal systems.
Stimulus	Failure and fault: Service off-line, error, crash ans so on.
Artifact	Back up, spare, communication channels.
Environment	Runtime, startup and shutdown, in-service.
Response	Able to response for many requests at the same time. Detect the fault. Recover from the fault. Prevent the fault.
Response Measure	Availability percentage(e.g. 99%) Time to be back to service after an error occured Time to detect a failure

Table 1: Availability Scenario

Portion of Scenario	Possible Values
Source	End users and internal systems.
Stimulus	Many requests come at the same time.
Artifact	A waiting queue or something could caching the request temporarily. A mechanism to serve the request after a short interval.
Environment	In-service.
Response	The C4 should be able to deal with a large bunchs of requests. And after a short interval, the request would be processed.
Response Measure	The time taken to serve every request. The lateness of the processing.

Table 2: Performance Scenario

1.2 Records of ADD iterations

1.2.1 Iteration 1

Chosen element: the whole system. Chosen ASR: 1. near 7x24 availability. 2. It should allow for "leaner" growth and should be able to grow at a rapid rate. Design Concerns: high availability, high scalability. Candidate architecture patterns:

pattern name	complexity	fault-tolerance
broker	low	low
redundant broker	high	high

Portion of Scenario	Possible Values
Source	Developers.
Stimulus	Add some interface to fit for a new requirement. Need to improve the system to cater for the increasing demand resulted from the rapid growing users.
Artifact	Code, interface, components and so on.
Environment	Runtime or off-line, in the design process or in the maintaining process
Response	Make the modifications.
Response Measure	The effort, time and money taken to implement such requirement.

Table 3: Modification Scenario

Portion of Scenario	Possible Values
Source	System customers.
Stimulus	More system customers or requests.
Artifact	Server cluster.
Environment	In the process of normal service provision of the system, the customers of the system grow from a small group to a huge network, or the number of customer requests grows rapidly.
Response	Scaling horizontally by adding servers, the cluster load is forwarded to the newly added servers.
Response Measure	Increase the workload of new servers; The ratio of system throughput improvement to the number of increased servers; The time the horizontal expansion takes effect, etc.

Table 4: Scalability Scenario

Chosen pattern: redundant broker Reason: Added broker can help manage server nodes and easily achieve high availability. But the business background goal that the system can handle requests simultaneously with highly growing customers will implies high pressure on the broker. Redundant broker is adopted for data backup quick switch in emergency condition.

1.2.2 Iteration 2

Chosen element: master. Chosen ASR: 1.can handle a batch of requests simultaneously and can support multiple agents. 2.should manage a big cluster/allow for "leaner" growth 3.near 7x24 availability. 4.identification, monitoring, and elimination of processing bottle-necks Design Concerns: Master Self-test Real-time Server Detection:Health detection Server Recovery: Fast restart, Trans-

Portion of Scenario	Possible Values
Source	Communication between systems and outside systems.
Stimulus	The system initiates data manipulation requests from other systems or processes data manipulation responses from other systems.
Artifact	Protocol module, Asynchronous communication module (including message queue).
Environment	During normal operation, the system needs to request relevant data from other systems or persist the data generated by the system to other systems.
Response	When a system makes a request to another system, it encapsulates the request event or data into a message in a predefined format. When processing the response of other systems, the message in the predetermined format is parsed into the event or data format within the system. In synchronous communication, the order of request events is guaranteed to be executed through synchronous message queue. After issuing the request, the system should wait for the response from other systems and then carry out subsequent operations. In asynchronous communication, after the system issues a request, it continues to carry out subsequent operations without waiting for the response. When the response messages of other systems reach the system, they will be cached in the message queue. The asynchronous communication module periodically checks the message queue and processes the relevant messages to be processed.
Response Measure	The proportion of communicating messages that are properly processed; The proportion of messages communicated being correctly rejected; Communication delay; Average number of message transfers per communication (encoding efficiency); Communication throughput.

Table 5: Interoperability Scenario

parency to PC, Data recovery Service Registry: Locating nodes, Resource allocation, Resource collection, Horizontal extension

Candidate architecture patterns/tactics: Master Self-test: pattern name, detection latency Hot spare, ¡100ms Warm spare, ¿1s Cold spare, ¿5s

Health detection: pattern name, communication pressure, storage pressure, report threshold, rate, transparent to PC Loading table, high, high, no, controllable, yes Server warning, low, low, controllable, up to context, almost PC warning, no, no, uncontrollable, up to context, not

Fast restart: ...

Transparency to PC: ...

Data Recovery: ...

Service Registry: ...

Portion of Scenario	
Source	Th
Stimulus	
Artifact	
Environment	
Response	mult At config will be rejected and fail. When the customer is interrupted during the configuration re
Response Measure	The time cost of context saving and recovery; Granularity of distrib

Table 6: Data Consistency Scenario

Portion of Scenario	Possible Values
Source	The client is going to request related infomation from the target server , usually the important personal infomation
Stimulus	The infomation sends back to the client
Artifact	Client PC
Environment	Query from DB , server cache and Request queue
Response	The server has to fetch the user request and conduct the related query from the data source, with the maintainance of the data integrity. To maintain the data integrity , the server should checkout whether the data has the lattest version and no other conflict writing conduction is on going.
Response Measure	The data sent back to the user has to be 100 percents integrity.

Table 7: Integrity Scenario

Locating nodes: ...
Resource allocation: ...
Resource collection: ...
Horizontal extension: ...
Chosen pattern/tactics: Master Self-test: Hot spare Chosen reason:
Health detection: Loading table

Portion of Scenario	Possible Values
Source	More customer load push on the system
Stimulus	More than five thousand of user are using the system
Artifact	Master server , keeper
Environment	Network connection , agent requests
Response	The server should detect the specific server that is overloadded, and reallocate the request to other leisure node; The keeper should arrange the request queue to ensure the syncronize the data flow in the process , ensuring the data is always correct.
Response Measure	Load balance , horizontal expansion and reqeust queue to resolve the high concurrency

Table 8: Availability Scenario

Portion of Scenario	Possible Values
Source	One agent somhow choose to save the session and return back to continue the session.
Stimulus	The system is going to save the context of the current session of agents.
Artifact	A session which represents the current state of both agents' infomation , session attributes and so on.
Environment	keeper
Response	The keeper reply the saving request and put the session infomation to the base storage in keeper's cluster , and set back the session identification to agents.
Response Measure	Set up local storages which is reponsible of saving sessions in the server of keeper and arrange the location of the storage.

Table 9: Usability Scenario

Fast restart:
Transparency to PC: ...
Data Recovery: ...
Service Registry: ...
Locating nodes: ...
Resource allocation: ...
Resource collection: ...
Horizontal extension: ...

1.2.3 Iteration 3

Chosen ASR: 1. should resolve and merge event conflicts. 2. able to maintain connection context Design Concerns: Resource Consistancy Maintenance: Detect data conflicts, Restore unconsistant data, Prevent data conflicts Context Recovery: Storage and restorage, Fault detection

Candidate architecture patterns/tactics: Detect data conflicts: pattern name, time consumption, detection lateness Data relation model, high, low Multiple backups comparison, low, high

Restore unconsistant data: pattern name, probability for lossing data, time consumption Roll back, middle, low Multiple backups restore, low, high

Prevent data conflicts: pattern name, difficulty, reliability Transaction, hard, high Retry, simple, efficient to conditional conflicts but not internal ones

Storage and restorage: pattern name context storage

Fault detection: pattern name, able to detect fault Redundant backup, yes No redundant, no

Chosen patterns/tactics: Detect data conflicts:Multiple backups comparison reason: There are multiple servers in keeper module, resulting to natural achievement of multiple backups.

Restore unconsistant data: Multiple backups restore reason: The same as above.

Prevent data conflicts: Transaction reason: Retry is unreliable.

Fault detection: Redundant backup reason: Redundant backups are necessary.

1.2.4 Iteration 4

Chosen ASR: 1.can communicate with other systems asynchronously. 2.can well communicate. Design Concerns: 1.Asynchronous communication: Asynchronous requests, time-out detection 2.Good communication: Satisfy interface, Reduce messages.

Candidate architecture patterns/tactics: Asynchronous requests: pattern name, priority, customization, complexity Message queue, no, no, low Scheduling, yes, yes, high

Time-out detection: pattern name, report rate, complexity Retry, 0.5s, middle Report, 0.1s, low

Satisfy interface: pattern name, has performance bottle-neck, extra pressure Distributed protocol, low, no, no Special intensive protocol, high, yes, on special module Master centric protocol, high, yes, on master

Reduce messages: pattern name local storage

Chosen patterns/tactics: Asynchronous requests:Scheduling reason: Priority is needed.

Time-out detection: Time-out detection: Report reason: retry is not necessary.

Satisfy interface: Distributed protocol reason: Introducing special will lead to a series problems about data consistancy. Cannot bing more pressure to

Master module which is the main entrance of the system.

2 Final Software Architecture Documentation

2.1 Documentation Roadmap

2.1.1 Scope and summary

This documentation is built for presence, explanation and analysis of the architecture of Call Center Customer Care(C4) System, which will be employed by ** US telecommunication company. In this documentation, expression and illustration of modules and theirs relationship will be covered, but not all functions of the system are included.

2.1.2 How the documentation is organized

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2.1.3 View overview

4 Views are employed to illustrate the architecture, including:
Decomposition view: The elements of this view are static modules, and connections illustrate their relationship.
Shared-data view: We using this view to express how important data are shared and protected from inconsistency resulted by business events....
Deployment view: This view also illustrate different parts of the software. Distinguished with module view, it focuses on the runtime status rather than the static status of the system.
All of the three views are following the standard UML specification.

2.1.4 How stakeholders can use this documentation

Use for specification, evaluation, development, test, deployment.

2.2 How a View Is Documented

Refer to the view template

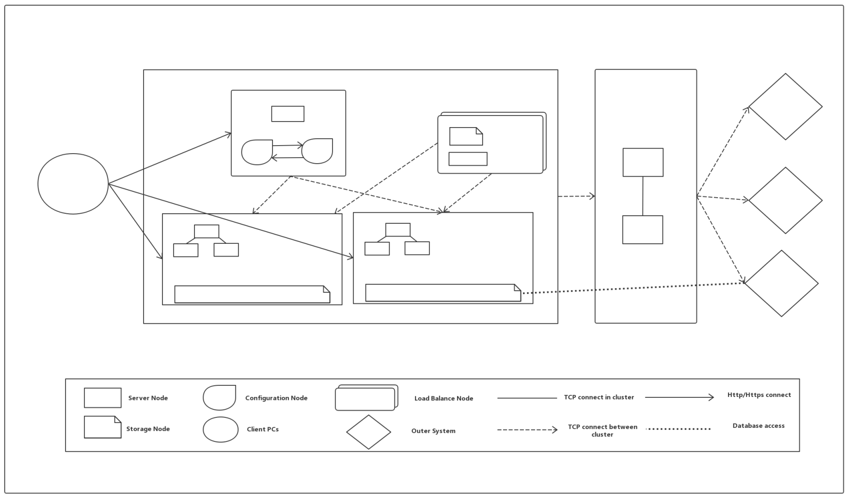
2.3 System Overview

System functions, users, important background, constrains.

2.4 Views

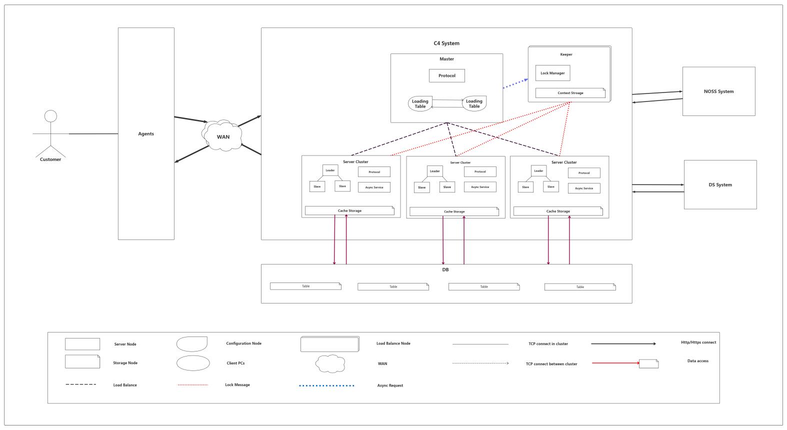
2.4.1 Decomposition View

Section 1: The Primary Presentation



Section 2: The Element Catalog The C4 system is consisted of these important sub-module to decompose: master node , normal server node , storage node , configuration node , load balance node. To resolve the normal phone request (contains the sync-request and async-request) , the normal server nodes are responsible to tackle the service from customers. Moreover , the storage nodes have to save the current session , cache the query on DB , and other cache to the locks . Load balance node has to detect the load in the whole system , and reschedule the load accordingly.

Section 3: Context Diagram



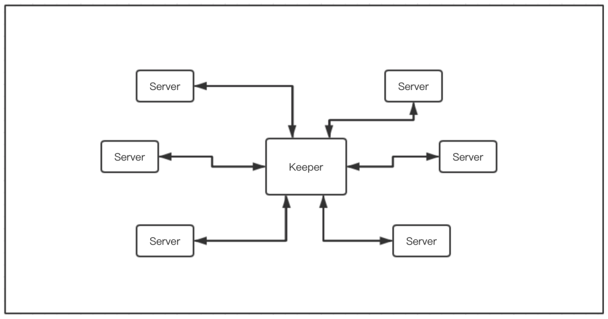
Section 4: Variability Guide The decomposition view represents the template module in the C4 system , and to exercise the variation points , you are

recommended to run the server node. With the sync-request (like fetching user basic information , setting up a new session) and async-request (conflict between the different sessions) , you could catch the key points in the master.

Section 5: Rationale The PC agents communicate with C4 system across the WAN. Master node stands for the whole manager of C4 system . That is , the master node uses the loading table to temporarily record the load status of all subordinate slave server clusters, and can timely alarm and resource reallocation. The master node also contains a protocol subnode, which is mainly used to help the master node process user requests. After the agents send the request, they will first be parsed by the master node to inform the agents of the required service node location, and then the agents will send the request to the target server. The keeper is responsible for asynchronous event processing and session saving between server nodes. Use Lock Manager to allocate locks and save contexts through context storage. The server node is mainly responsible for periodically reporting heart beat status to the master node, and can perform hot backup between nodes. Please note that one server node here is also a cluster. In our design, one cluster is responsible for a certain range. The service (similar to the microservices architecture), and the leader is elected by the vote inside the cluster to perform resource scheduling and service allocation to the subordinate slave. In addition, the server node also supports the processing of the protocol and async service. Responsible for the interaction of the NOSS and DS systems. The cache storage is responsible for the caching of the external DB system. Since each business request will design a query of more than a dozen data tables, considering the time loss of the cascaded query, we use the cache mechanism to The query result is cached inside the server.

2.4.2 Shared-Data View

Section 1: The Primary Presentation



Section 2: The Element Catalog

Elements and their properties

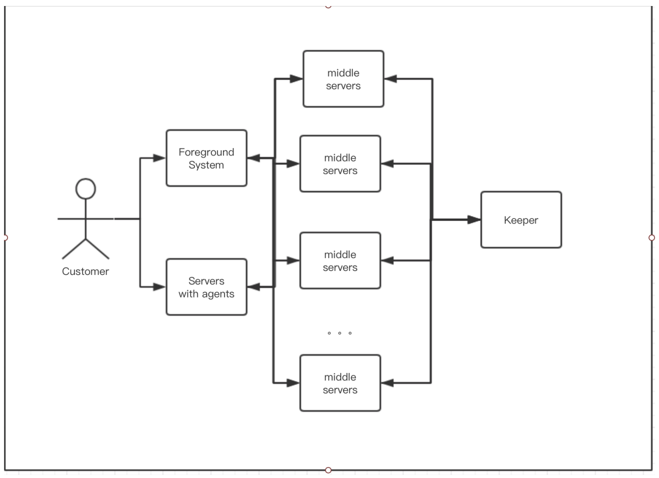
- Keeper The keeper is a data storage center which holds the shared data.
- Server The server is an entity which stores and fetches data from the Keeper. For example, when a customer temporarily terminates the process, server should save the context for a future reference.

Relations and their properties During the fetching process, there may not exist the record, so there should be an exception. Also, in the saving process, to those records that already existed, saving process should be an update to the old version.

Element interfaces The Keeper should provide the find and insert interfaces to the servers.

Element behavior The servers save and fetch the data from the Keeper.

Section 3: Context Diagram



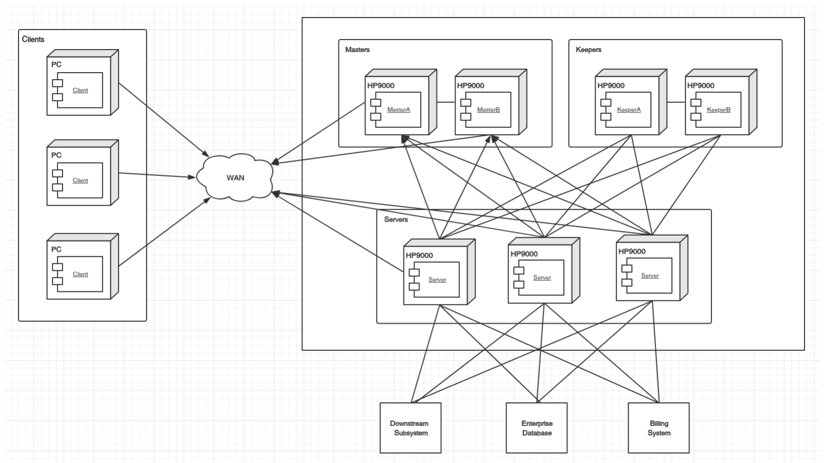
Section 4: Variability Guide Because the data storage is not the only responsibility keeper takes, so in the future, it may be divided into several more specific components, that is to say, the keeper in this view may be changed to a data repository or other data center.

Section 5: Rationale The design problem came from the requirement "A customer can be interrupted (for technical reasons, for example) or suspended by the customer or the representative ... In any case, C4 has to manage the context that persists and can be recalled." In order to do this, there should be a mechanism that stores and fetches the context. There are several options. For example, we can save the information in the agent's PC, or save in the

DB provided by the third party. But both of them are infeasible. There is no persistent data caching on the agent workstations, and DB may not be changed since it is provided by the third party. So finally, we choose to save the information in the Keeper, as it is also used to synchronize the event and resolve the conflict as mentioned in the sections before.

2.4.3 Deployment View

Section 1: The Primary Presentation



Section 2: The Element Catalog

Elements and their properties

- Client The element Clients are deployed in the physical nodes placed in the office, which is running on Windows 10 PC.
- Master The master node of server cluster, providing functionalities such as load balancing, service registration, and service management. The master node is deployed independently to two HP9000 servers through dual hot standby mode.
- Server Server is the node that provides business service processing capabilities in the server cluster and is deployed on multiple HP9000 servers. These server nodes are redundant nodes and provide the same business service processing functionality.
- Keeper Distributed service coordination node, providing distributed locks and service processing context storage for server node cluster.

Relations and their properties

- Client Processing the business by communicating with the server cluster through the WAN
- Master Clients will request the Master to obtain services list and Master will return a suitable services list for Clients based on the current load.
- Server The actual request of Clients is directly performed with the Server, not Master; when the Server node starts, it will register the service with the Master node, keep connection with Master node during the normal service provision, and report the load status and other information to Master node; During the business processing, the Server nodes will communicate with other systems outside (including downstream subsystems, enterprise databases, billing systems, NOSS, etc.) when necessary.
- Keeper The Server node will obtain or release the lock from Keeper; when involving business interruption or recovery, the Server node will also save or obtain the business context from Keeper.

Element interfaces

- Client End user interaction interface
- Master Service registration interface; service list acquisition interface; load information collection interface
- Server All business function interface; synchronous/asynchronous communication interface with external system
- Keeper Read/Write interface of business context information; lock service interface

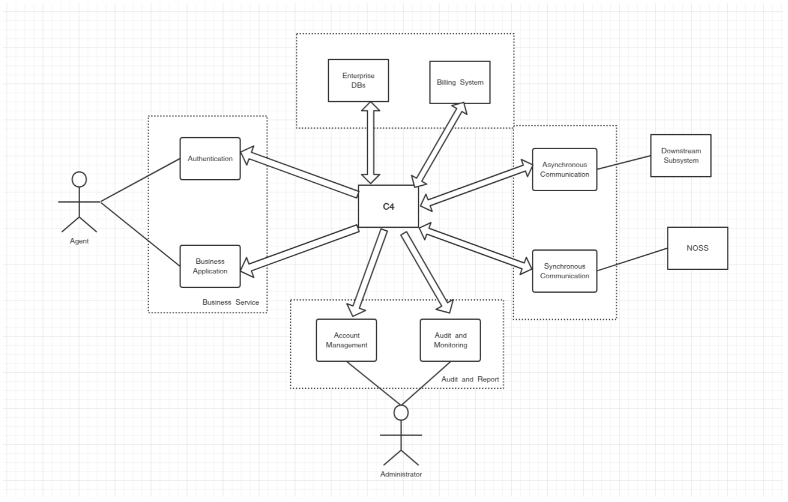
Element behavior

- Client Respond to end user interaction
- Master In response to the Client's service list obtaining request, Master will generate an appropriate service list and returns according to the current cluster load situation and the predefined load balancing policy; Collecting periodic load information reports from Server nodes; If load information report of a Server node is not received within the certain period, the Server node is considered to be failed, and will be removed from the service list; Accept and process service registration requests from eht new Server nodes
- Server Respond to Clients' business requests; Periodically processing asynchronous responses from external systems in the message queue; When Clients request to interrupt the current business, the Server will save the

current business context in Keeper, and when Clients request to restore the current business, Server obtains the stored context information from the Keeper and returns it; For each Client's business, Server will request Keeper to lock or release lock of related system resources

- Keeper Response to Servers' lock service request according to the current resources lock situation; Response to Servers' context read and write requests

Section 3: Context Diagram



Section 4: Variability Guide With the growth of business in the future, the number of office agents will increase, so the number of Client nodes that need to be deployed will also increase. In order to cope with the larger work load, the Server nodes will introduce more deployment nodes accordingly.

Section 5: Rationale Because of the high availability requirement of the system, the system needs to respond to the failure of the Server nodes through redundancy (including Client nodes and Server nodes). Secondly, in order to coordinate the management of distributed Server node cluster, we introduce the Master node to implement service registration and service management, and in order to solve the single point failure, Master nodes adopt the scheme of dual-system hot standby and physical node independent deployment.
Since the concurrent tasks in the normal service processing may cause problems such as configuration requests conflicts and system resource conflicts, and the requirement of saving the interrupted business context, the system needs to ensure data consistency under distributed clusters.Therefore, we introduces Keeper to provide the functionality of distributed lock, and in order to solve the problem of single point failure, Keeper nodes also adopt cluster mode and independent physical node deployment.

2.5 Mapping Between Views

Section 1: Mapping Selection After designing the first three views, we found that the deployment view and the decomposition view are very similar, so we plan to measure and show the relationship between them.

Section 2: Mapping Graph

Element in Deployment view	Element in Decomposition view
Masters	Protocol, Loading Table
Keepers	Lock Manager, Context Storage
Servers	Leader, Slave, Potocol, Async Service, Cache Storage
Clients	PCs / Agents

Table 10: Mapping Graph

Section 3: Mapping Description It is not difficult to see that the two views (Deployment and Decomposition) of the C4 system
are almost identical at the cluster level, and all adopt the basic Master-Slave architecture mode.
On a more granular level, the Masters implementation adopts the Protocol.
And the implementation of the Keeping Table; keepers are implemented by Lock Manager and Context Storage, so the keeper has the coordination function;
the working cluster Servers are implemented by Leader, Slave, Protocol, Async Service, Cache Storage, and external systems and agents. Interact.
In addition, Clients are implemented by multiple PC physical machines.

2.6 Rationale

Explain what decision we have made in our views.

2.7 Directory

3 Personal Remarks

3.1 Statement of ...

3.2 Statement of Peihong Chen

1: ADD experience ADD is a practical software architecture design method, the overall design is a top-down progressive refinement, and after several rounds of iteration, it makes the software designers to progressively deeper understanding on the system. Each iteration is independent and interrelated, because each round of iteration will only focused on one or a few specific quality attributes, which can avoid unnecessary interference; In addition, subsequent iterations can also conduct a deeper analysis based on the previous iteration, so there is some relationship between iterations. The cycle continues until the architectural elements and responsibilities of the entire system are clear.

2: Contribution During this assignment, in the early stage team members participated in functional and non-functional requirements analysis and ASRs identification. Then, in all the four iterations, team members discussed together, exchanged opinions and made decisions on some vague points. My main contributions are scalability, interoperability and data consistency of stimulation corresponding sequence, the second iteration of service recovery (including quick restart, transparent to PC, and data recovery) and resources in the third iteration consistency (including detecting data conflicts, restore data inconsistency, and prevention of data). In addition, in the documentation process, my main contribution is writing the deployment view and working with other team members to complete the cross-view.

3.3 Statement of Shaoxun Zeng

1: ADD experience I feel it is difficult to narrow down the focuses. For example, in the ADD second iteration, we choose the "broker node" to break down. And we brainstormed many ideas, but when we came to the "Design Concerns" section, it is difficult to summerize them into several main categories. Also, figuring out the tactics used to solve the architetural requirements is a big deal to me since we lack the development experience. I could only do my best to "imagine" the real situations combined with the information gathered from the Internet. In a nutshell, it is useful to follow these steps. In the last phase, when I put all the parts together, I find it is natural to reach the final result with our refinement, which is not such an obvious result from the first glance of the requirement document.

2: Contribution During the disccusion, I participated in the whole process. More specificly, I wrote some scenarios of the ASR, participated in the all iterations of ADD, gave out some tactics and requirement specifications, documented the Shared-Data View. And also, I think I pushed the whole process during the disccusion. For example, when we stuck in the brainstorming, I suggested to move on and came back to this point a fewer minutes later. And also, since we use the latex for formating, I do a lot of works about the formating.

3.4 Statement of Fangming Lu

1: ADD experience In the process of using ADD, special attention should be paid to the selection of ASR,
because it will affect the final result. The initial ASR needs to be given in detail, taking into account the key points in the demand.
For example, the same in this C4 system. Asynchronous problems, conflict resolution problems, what kind of effects are needed to be realized at the beginning, and can be well targeted for subsequent tactics.
In addition, in the selection process of the view, the factors that need to be considered are beyond the expectations of the beginning.
In order to get a more objective view selection, each participant in the process from product demand to release is evaluated for importance.

2: Contribution Participated in each iteration process, participated in the planning of the master service registration function,
imitated the typical master-slave architecture, and gave the node design, resource allocation, resource recovery, horizontal expansion of the architectural design.
Also responsible for integrity , reliability, ease of use of the Scenario design, and gives the five section design of the decomposition view

3.5 Statement of ...