TASI

TELECOMMUNICATIONS AND SOCIAL INFORMATICS
RESEARCH PROGRAM

Massively Learning Activities

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1 | Abstract

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2 | Introduction

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2.1 | TASI/PHIDC

ABOUT US

The Telecommunications and Social Informatics Research Program / Pacific Health Informatics and Data Center (TASI/PHIDC), formerly TASI/PEACESAT, is part of the Social Science Research Institute (SSRI) of the College of Social Sciences (CSS) at the University of Hawai'i at Manoa. TASI/PHIDC programs incorporate an interdisciplinary approach to education and research, and work with partners from across the University of Hawai'i system, State of Hawai'i and other government and academic institutions from the Asia and Pacific Islands region. Program and research focus areas include policy, planning, information and communications technologies and systems, health information technology, health informatics in Hawai'i and the Pacific Islands region.

MISSION

The TASI/PHIDC Research Program missions are to: (1) Provide technical assistance in policy, program planning and evaluation; (2) Facilitate public and private sector collaboration to improve community resiliency, sustainability, and health system performance; and (3) Build capacity in information technology, health data management, analytics, and data sciences.

FACULTY RESEARCH

TASI/PHIDC conducts interdisciplinary and applied research and provides policy, program, technical assistance, education, and training in Hawai'i and the Pacific Islands Region related to:

- Accessible and affordable Information and Communication Technology (ICT)
- Health Information Technology (HIT)
- Electronic Health Record (EHR)
- Healthcare and claims data management, analytics, and programs
- Telehealth
- Meteorological and disaster communications

2.2 | Contract Explained (TBD TITLE)

TASI/PHIDC is a Technical Assistance and Research Partner or "TARP" who has an Intergovernmental Cooperative Agreement (ICA) with the Commonwealth of the Northern Mariana Islands (CNMI) State Medicaid Agency (SMA) to design an infrastructure that would allow advanced data analytics and parallel processing of Protected Health Information. After careful consideration, TASI/PHIDC has opted for SAS technologies in a hyper-converged infrastructure.

- Modernize data archive and storage (paper to electronic) of PHI data.
- Want to perform data analytics and machine learning.
- Used RCUH funds to purchase SAS license.
- Therefore, SAS needs to be accessible to multi-tenants and UH themselves.

3 │ What is Hyper-Converged Infrastructure (HCI)

HCI, or Hyper-Converged Infrastructure, is a software-defined, unified system that combines the traditional elements of IT infrastructure (e.g., compute, networking, management, storage) with virtualization, simplifying infrastructure, reducing costs, and increasing scalability and flexibility. In a traditional IT Infrastructure, servers, storage networks, and storage systems are physically separated as stand alone hardware devices (e.g., servers, network switches, disk arrays). Consolidating these components into a single, integrated system simplifies the management, deployment, configuration, and maintenance of your IT Infrastructure.

The benefits of an HCI environment include:

- Scalability: Designed to scale out by adding additional nodes on-demand to your system.

- Efficiency: Improve resource utilization by using or eliminating idle storage capacity.

- Agility: Quickly deploy new applications and workloads without extensive planning across systems.

- Data Protection: Integrated backup and disaster recovery.

- Reduced Hardware Costs: Reduce the amount of hardware required reducing CAPEX[1]/OPEX[2] costs.
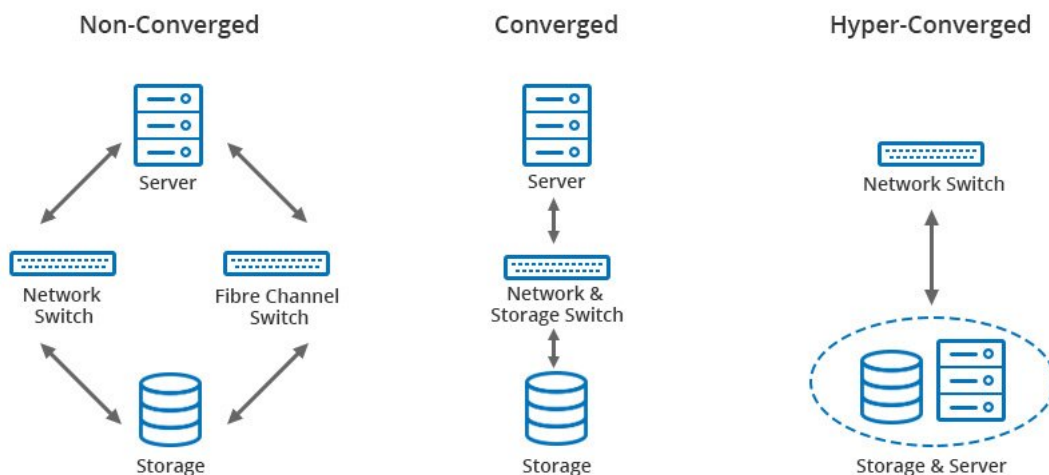

Figure 3.1: Types of IT Infrastructures (STOLEN EXAMPLE)

In HCI, multiple servers (nodes) are combined together to create a cluster. Nodes part of the cluster can share their storage and computing resources with other nodes to create a multi-purpose integrated system. The design of your HCI is dependant on (HPC Cluster?)

The software also provides a management layer, which automates tasks like resource provisioning, data migration, and load balancing while abstracting the hardware.

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[1]Capital expenditure is the cost a business incurs to acquire assets that will provide benefits beyond the current year.
[2]Operating expenses refer to the money a company spends to run day-to-day operations.

4 │ What is Statistical Analysis System (SAS)?

SAS, or Statistical Analysis System, is a software suite that has been used for advanced analytics, business intelligence, data management, and predictive analytics since it was first released in 1976. Developed by the SAS Institute, it offers a range of statistical and data analysis tools, which are suitable for many applications including data mining, forecasting, econometrics, quality control, and statistical analysis.

The software provides a user-friendly graphical interface for data analysis and reporting, as well as a powerful programming language that allows users to customize their analysis and automate repetitive tasks. Its ability to handle large and complex datasets and perform advanced statistical analyses make it popular in various industries, including finance, healthcare, government, and academia. SAS is widely used for purposes such as fraud detection, risk management, clinical research, and marketing analysis, and is a popular choice among data scientists and statisticians.

SAS offers multiple product **suites**. The SAS Enterprise Suite is a collection of SAS products designed for enterprise-level data management and analysis, such as SAS 9.4, SAS Visual Analytics, SAS Data Integration Studio, SAS Data Management, etc. The SAS Platform provides two engines for managing foundational capabilities such as distributed processing, security, administration, program development and execution, resource management, user interfaces, cloud integration, operating systems and third-party software. These engines are **SAS 9.4** and **SAS Visual Analytics**.

4.1 │ SAS 9.4

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4.2 │ SAS Visual Analytics (SAS Viya)

SAS Viya, or SAS Visual Analytics, is a cloud-enabled, in-memory analytics engine that provides elastic, scalable, and fault-tolerant processing for advanced data analytics, data processing, and machine learning for enterprise environments. SAS Viya includes a variety of tools such as SAS Visual Analytics, SAS Visual Statistics, SAS Data Mining, and SAS Machine Learning. When performing analytics on large datasets, SAS Viya uses a distributed in-memory processing engine called **CAS**.

4.3 │ Cloud Analytics Services (CAS)

Cloud Analytics Services (CAS) is the in-memory analytics engine SAS Viya uses for both on-premise as well as cloud-service environments (e.g., AWS, Azure, GCP). CAS uses a combination of hardware and

software where data management and analytics take place on either a single-machine or as a distributed server across multiple machines. In either single or distributed deployment, each machine (host, node, etc) will be assigned one of three roles: CAS Controller, CAS Backup Controller, CAS Worker.

Analogy

In a restaurant kitchen, there exists three primary chefs. They are the (1) executive chef, (2) sous chef, and (3) station chef(s). The executive chef's primary role is to manage the kitchen and its staff whilst doing very little cooking. The sous chef's primary role is to be the right-hand to the executive chef, ready to manage the kitchen, share, or take over the responsibility of the executive chef at a moments notice. The station chef(s) merely wait for instructions from the executive chef, then executes the job they are given.

This is the relationship of each CAS node with each other:

- The CAS Controller is the executive chef managing the kitchen and its staff, delegating work.

- The CAS Backup Controller is the sous chef ready to take over the responsibility of the executive chef.

- The CAS Worker(s) are the sous chefs cooking what they were assigned to by the executive chef.

4.3.1 | Role 1: CAS Controller

Controller is the first role that can be assigned to a host for SAS Cloud Analytic Services. For both server architectures, single-machine and distributed, one machine must be designated as the Controller. The role of the Controller is to parse out work to each Worker host available. In other words, the Controller manages and controls the overall operation of the CAS environment. As the master node, the Controller is responsible for distributing workload among available CAS Workers, managing user sessions, and providing a secure environment for data retrieval and data storage.

In a single-machine environment, the CAS Controller and CAS Worker roles can be performed by different processes or threads within the same operating system instance. However, we are not limited to this deployment method as it is also possible to have the CAS Controller and CAS Worker(s) virtually separated (on the same hardware) to increase the scalability of the deployment. The configuration of your architecture depends on what you need out of CAS.

In a distributed environment, the CAS Controller is responsible for managing and controlling the CAS environment whilst the actual data processing and data analytics are performed by the CAS Worker(s).

4.3.2 | Role 2: CAS Backup Controller

Backup Controller is the second role that can be assigned to a host for SAS Cloud Analytic Services. Although optional, the CAS Backup Controller is highly recommended in a distributed server environment. The role of the CAS Backup Controller is to act as a standby or hot-backup for the primary CAS Controller in case of a failure. Its primary purpose is to ensure that the system can continue to function in the event of a failure of the primary controller. The Backup Controller is typically set to passively monitor the primary controller for any signs of failure, such as a loss of connectivity or failure to respond to heartbeat messages. It does not actively participate in task scheduling or job execution while the primary controller is running normally.

If the primary CAS Controller fails, the Backup Controller will take over as the primary controller and assume responsibility for managing the CAS worker nodes and scheduling tasks. In this scenario, the CAS worker nodes will send their status updates and job results to the Backup Controller instead of the failed primary controller.[3]

In some systems, the Backup Controller can also be given jobs to execute as a CAS worker node. This can help to improve the system's overall performance by increasing the number of available processing resources. In this scenario, the Backup Controller can perform both the role of a CAS Controller and a CAS worker node.[4]

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[3]If the main CAS Controller fails, how does each CAS Worker respond to the Backup Controller with their completed jobs?
[4]Can the CAS Backup Controller be assigned work as well as passively monitor the main CAS Controller?

4.3.3 | Role 3: CAS Workers

Worker is the third role that can be assigned to a host for SAS Cloud Analytic Services. The CAS Worker is responsible for performing data processes and data analytics sent from the CAS Controller. For example, CAS Workers can perform data manipulations, transformations or computations on large/complex datasets. These computations are but not limited to: statistical analysis, machine learning models, text analysis, time series analysis, optimization, etc. Workers execute these computations using data stored on disk, in-memory, or in a distributed file system.

In a distributed environment, one host will be assigned as your controller and any additional hosts are considered workers (optional CAS Backup Controller). Workers increase the overall computing power of your distributed-server and provides a solution for a scalable (up/down), distributed, and fault-tolerant environment for data storage and data analysis because the worker manages the storage of data/metadata across multiple nodes. The amount of CAS Workers needed to create an optimized distributed environment is highly dependant on data size, computation type, and workload.

Using these three roles, we can create two types of CAS configurations: a single-machine environment using symmetric multiprocessing **(SMP)**, or distributed server environment using massively parallel processing **(MPP)**.

4.3.4 | Symmetric Multiprocessing (SMP)

Symmetric multiprocessing (SMP) is an environment where a CAS server consists of one controller that runs on a single machine. The functionality for a single-machine server is nearly identical to MPP, except that there is no cluster communication. In this architecture, the server acts as a controller. Before a client connects, the server listens on a port for connections. A server running in SMP mode consists of a controller only, and the server starts a session controller process only. It is the session controller process that operates on rows of data.
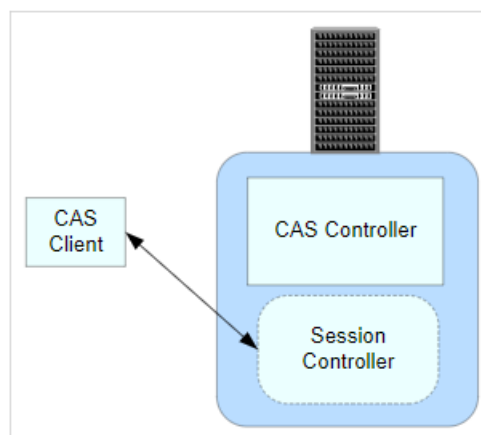

Figure 4.1: Single-machine CAS Server (STOLEN EXAMPLE)

4.3.5 | Massively Parallel Processing (MPP)

Massively Parallel Processing (MPP) is an environment where a distributed CAS server consists of one controller, one or more workers, and one backup controller (optional), each running on a separate machine. In a distributed server (MPP mode), a session process is created on each machine in the cluster. These processes are sometimes referred to as the session controller and session worker processes. Even though the sessions have their own operating system processes, the server processes must continue to run. When the server process terminates, the session processes also terminate.
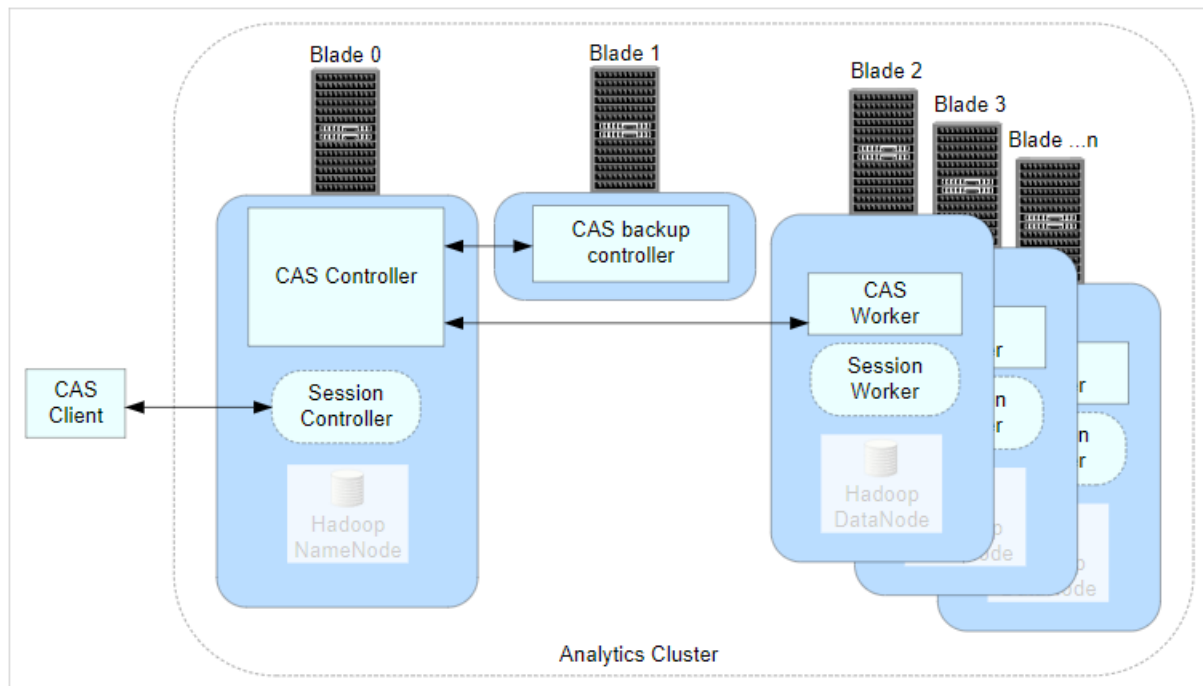
Figure 4.2: Distributed CAS Server (STOLEN EXAMPLE)

5 | Massively Learning Activities

- We are contracted by CNMI to create an infrastructure where we can perform data analytics on PHI. This infrastructure is hosted on-prem first, hybrid later.

- Tenants (e.g. APCD, CMNI, CMA, Criminal Justice) has the data ready.

- Data is submitted from tenants to ETL (data-pipeline) to be processed then sent to SAS (on-prem servers).

- Data analytics is performed on the data using advanced algorithms in SAS programming language.

- Project is time sensitive, deadline is requiring TASI to move onto the development stage with existing on-prem hardware as proof-of-concept ASAP.

- Initially architect the infrastructure using existing on-prem hardware to speed up deployment

- Once deployed, stable, and proof-of-concept ready, move onto the production stage by acquiring new hardware and migrating the previous (virtualized) SAS deployment to the new hardware using vMotion..

- Configure the security relationship between the software, hardware, and tenants (Active Directory, LDAP, Security Groups, etc.

5.1 | SDLC

A │ Appendix A title

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