Task – Air Traffic Control

Background

Air traffic control (ATC) is a service provided by ground-based air traffic controllers who direct aircraft on the ground and through controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. The primary purpose of ATC worldwide is to prevent collisions, organize and expedite the flow of air traffic, and provide information and other support for pilots. To prevent collisions, ATC enforces traffic separation rules, which ensure each aircraft maintains a minimum amount of empty space around it at all times.

As a flight progresses from its departure airport to its arrival airport, it deals with several ATC entities that guide it safely through each portion of the airways it is using:

- *Ground control* coordinates the movement of aircraft on the ground at an airport.
- *Towers control* aircraft flying within an airports terminal control area.
- *Area control* divides the sky into sections of responsibility to provide services to aircrafts when flying between airports. Our software system focus on this ATC entity.

Functional requirements

The ministry of aviation develops a new ATC area control software application.

An area control center has the following structure:

- Each area control ATC center has several sectors, where sectors are defined in ways unique to each center. They may be defined to balance the load among the center's controllers; for instance, less-traveled sectors may be larger than densely flown areas.
- Each sector is required to have at least 2 controllers (2 employees) using 2 consoles (consoles are the air traffic controller's computers). The first is the radar controller, who monitors the radar surveillance data, communicates with the aircraft, and is responsible for maintaining safe separations. The controller is responsible for managing the tactical situation in the sector. The second controller is the data controller, who retrieves information (such as flight plans) about each aircraft that is either in the sector or soon will be. The data controller provides the radar controller with the information needed about the aircraft's intentions in order to safely and efficiently guide it through the sector.

The application is an extension to an existing legacy ATC system called “Host Computer System” (HCS). The new system should provide the following functionality:

- Handed off aircrafts from center to center and from sector to sector within each center.
- Acquire radar reports that are stored in the existing ATC system HCS.
- Convert the radar reports for display and broadcast them to all of the consoles. Each console chooses the reports that it needs to display; any console is capable of displaying any area.
- Handle conflict alerts (potential aircraft collisions) or other data transmitted by the HCS.
- Interface to HCS for input and retrieval of flight plans.
- Provide a recording capability for later playback.
- Provide graphical user interface facilities, such as windowing, on the consoles. Special safety-related provisions are necessary, such as window transparency to keep potentially crucial data from being obscured.

Non-functional requirements

The ATC area control application is hard real time, meaning that timing deadlines must be met absolutely; it is safety critical, meaning that human lives may be lost if the system does not perform correctly; and it is highly distributed, requiring dozens of controllers to work cooperatively to guide aircraft through the airways system.

1) *High availability*: the system (including also HCS) is prohibited for being inoperative for longer than 5 minutes per year. However, if the system is able to recover from a failure and resume operating within 10 seconds. That failure is not counted as unavailable time.
2) *High performance*: Able to process more than 2000 operations with aircrafts simultaneously. Taking into consideration that loads change during the day. It is expected that the process of interpreting radar data is processor intensive, and real-time. On the other hand, recordings analysis is processor intensive but could be done in the background.
3) *High scalability*: Flexibility in the number of consoles to each sector. The number could change while the system is in operation. It is expected up to 210 consoles per centre.
4) *High adaptability*: It's required to have the flexibility to control the distribution of consoles among sectors, and provide extensive monitoring and control information, such as network management, to allow site administrators to reconfigure the installation in real time.

Task goal

The architect would like to design and decompose the logical and physical architecture of the system. The logical architecture specifies the components of the system, and their relationships. While the physical architecture specifies the system components and their deployment on servers. Propose and model the logical and physical architecture for the system, which fulfils the requirements and constraints. In your design, specify and justify the components, their relationships, and the different architectural solutions (e.g. patterns), which you used in your design.

To design the logical architecture of the system, follow the following two steps:

1) Identify possible components of the system and their dependencies. A component could be for example a user interface component, a database or a processing component.

2) **Use the following patterns to structure the system**:
    a. Layers architecture pattern.

To design the physical architecture of the system, **use the following solutions**:

a. Cloud dynamic scalability architecture pattern
b. Active redundancy architecture tactic

The solution of the task is expected to be one or two architecture models and an explanation for the architecture, which justify the design decisions.