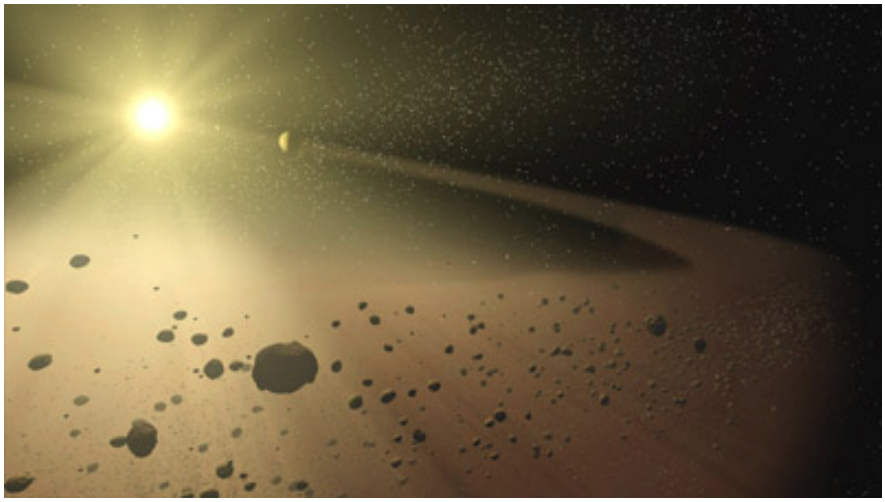
CSCI E-97
Assignment 5
Asteroid Exploration System Requirements
Due: Friday, December 20th

Introduction

The International Space Agency (ISA) has funded a new project to launch an aggressive asteroid exploration and mining program. The proceeds from discovered precious metals, including gold and platinum will be used to fund the development of a moon base. Construction of the moon base will leverage the materials mined from the inner belt asteroids and comets.

You have been selected to design the software system to manage a fleet of robotic spacecraft that will be sent to explore and mine the asteroids of the inner asteroid belt.

This document provides a brief project overview. It also provides a set of requirements which your design must satisfy.

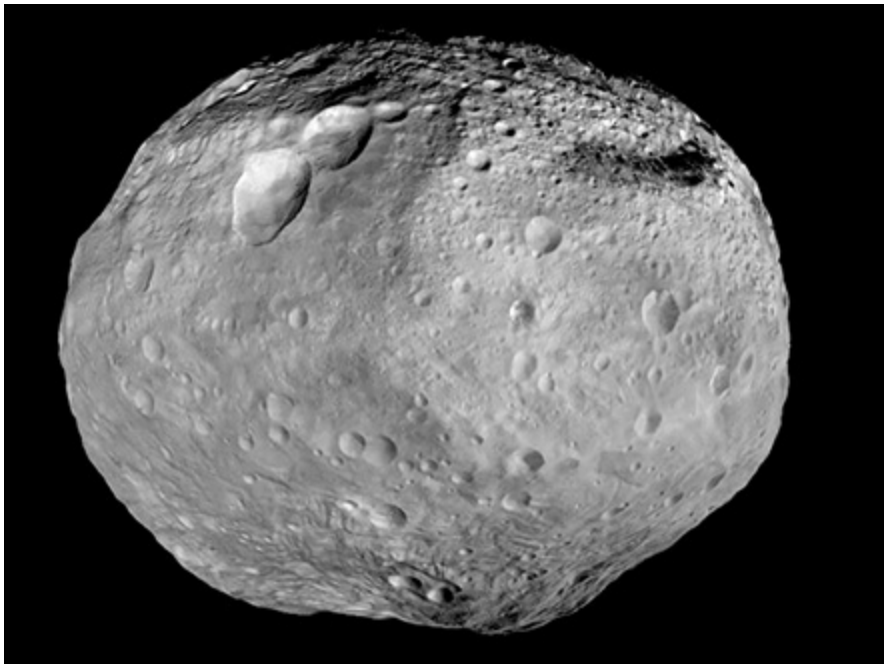


Caption: Artist image of the inner asteroid belt orbiting between Mars and Jupiter (NASA)

Overview

Recent discoveries show that the asteroids are a rich source of minerals, and in some cases contain water and oxygen. Advancements in space travel now make it possible to send robotic spacecraft to visit and explore the asteroid belt. Nasa recently sent the Dawn spacecraft to visit the Ceres and Vesta asteroids. Ceres and Vesta are the first and second most massive asteroids in the main asteroid belt. The main asteroid belt is positioned between Mars and Jupiter. Ceres is covered with a layer of ice and has a rocky core. There may be an ocean of

water below the ice layer. Like Earth, Vesta has a core, mantle and crust. The Dawn spacecraft has orbited Vesta, and is now on its way to Ceres, and should arrive in 2015.



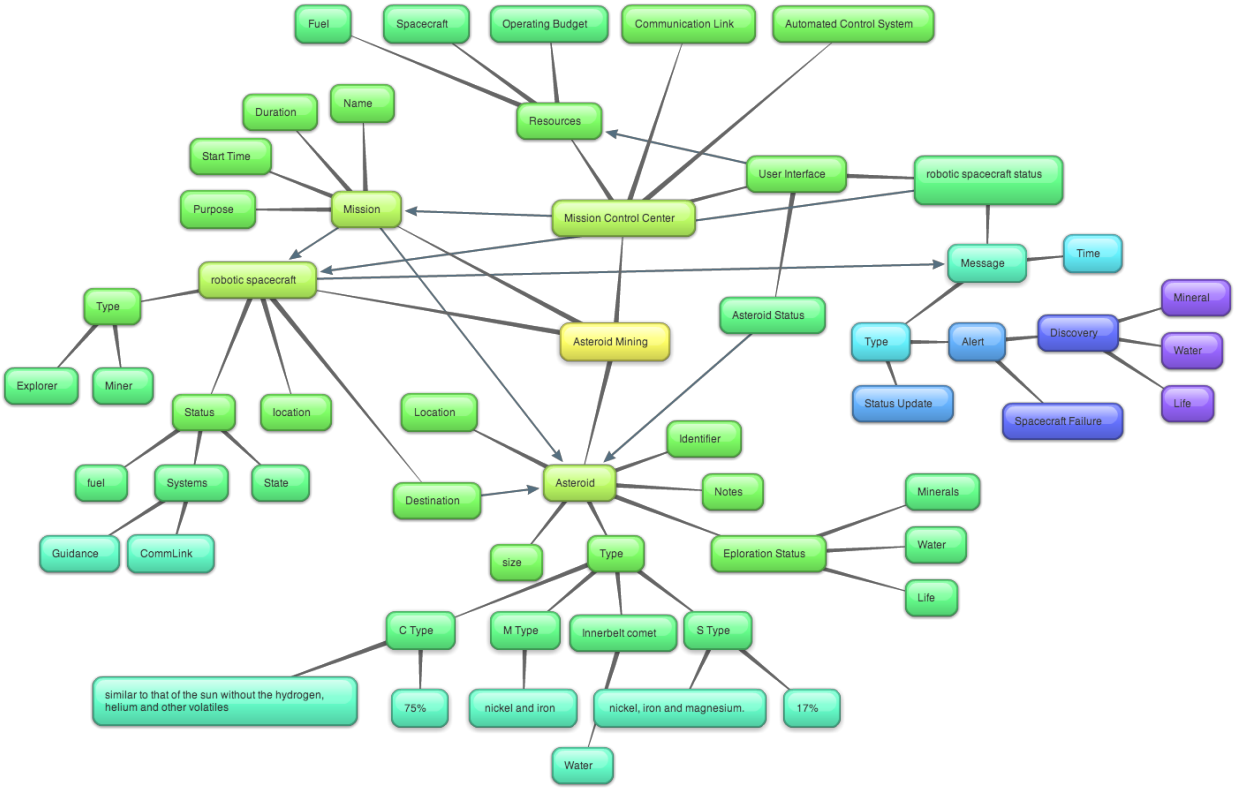
Caption: Image of the Vesta asteroid photographed by the Dawn spacecraft (NASA)

The natural resources contained within Asteroids can provide a source of monetary wealth. More importantly, they can supply the necessary resources for building remote outpost for human habitation on the moon, Mars, and other planetary bodies, as well as the spacecraft and fuel for traveling between them and beyond. The asteroids have near zero gravity fields, so the amount of energy required to transport the mined materials from the asteroid to the moon or Earth is minimal.

Caption: Artist rendering of future asteroid mining operation (How Stuff Works)

Requirements

The following diagram is a mind map of the Asteroid Exploration System.



Caption: Mind map of the Asteroid Exploration and Mining System.

Subsystems

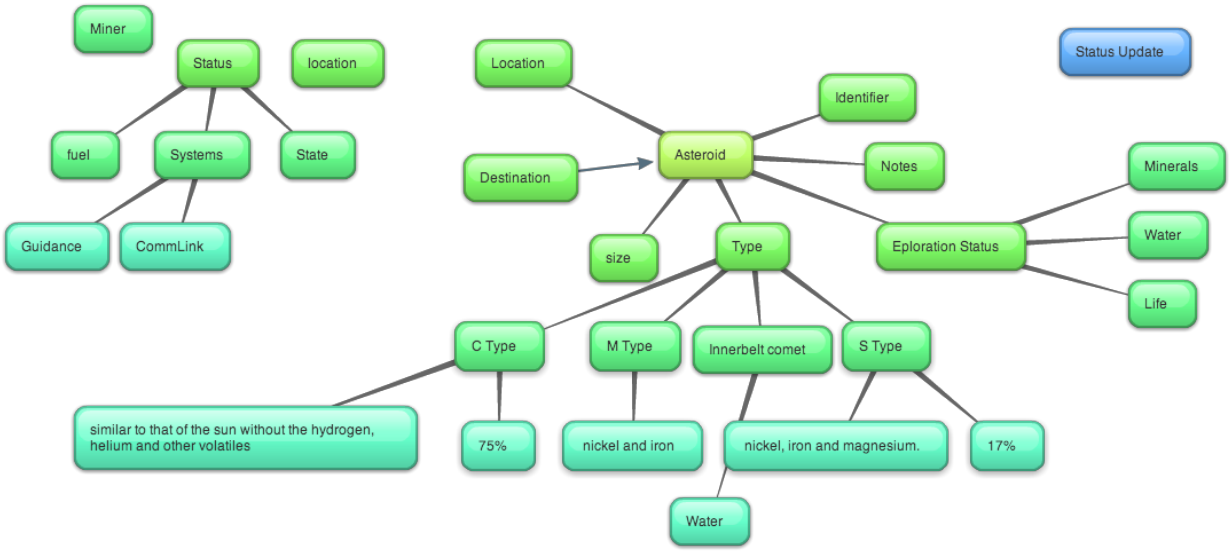
The Asteroid Exploration System is composed of the following subsystems:

- Asteroid Inventory System
- Robotic Spacecraft Management System
- Mission Management System
- Command and Control User Interface
- Authentication Service

The design should define a set of modules that map to the above subsystems. The modules will be loosely coupled and internally cohesive. This modular approach will target level 5 of the Modularity Maturity Model: Service Oriented Architecture. (covered in lecture 11)

Asteroid Inventory System

The Asteroid Inventory System is responsible for maintaining an inventory of all known asteroids and their features.



The Asteroid Inventory System manages the collection of known Asteroids and their associated features:

Identifier: the given unique identifier for the asteroid (e.g. 1 Ceres, 4 Vesta, 433 Eros, etc),
Notes: description and other notes about the asteroid. Notes can be added over time. Notes have a date, author and text.
Exploration Status:

- **Minerals found, estimated mass, accessibility** (e.g. platinum, 20 metric tons, surface deposit).
- **Water found, quantity, state** (e.g. yes, 20 million liters, ice)
- **Life** (none, single cell organisms, multi cell, intelligent, friendly)

Asteroid Type (C-Type, M-Type, S-Type, Innerbelt comet)
Size: width, length, height
Mass: approximate mass
Surface Gravity: gravitational field at surface
Aphelion: furthest distance from Sun in AUs
Perihelion: closest distance from Sun in AUs

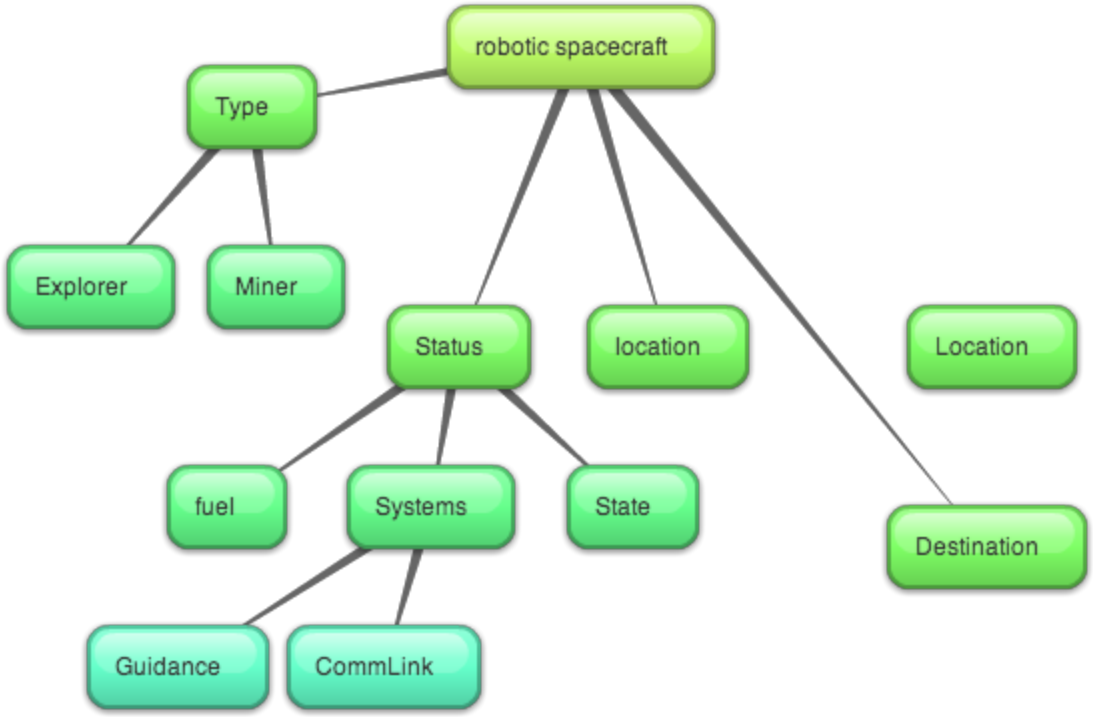
The Asteroid Inventory System must support the following interface functions:
List asteroids
Lookup Asteroid by Id
Create new and Update existing Asteroids
Query for Asteroids: Text Search: Search for matching text in notes.

All Asteroid Inventory System methods have restricted access.

Robotic Spacecraft Management System

The Robotic Spacecraft Management System is responsible for managing the fleet of robotic spacecraft.

The system maintains the current status of each of the spacecraft.



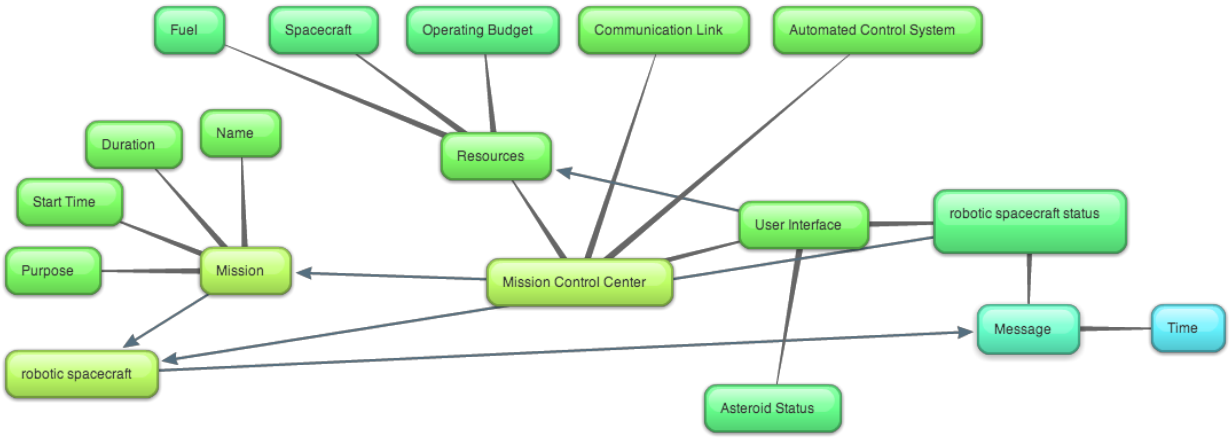
Each spacecraft has the following set of attributes:
Identifier: unique spacecraft call sign
Launch Date: date of launch
Mission: mission identifier
Type (Explorer, Miner)
Status
    Fuel (% remaining)
    Systems
        Guidance (OK, Not OK)
        Communication Link (OK, Not OK)
    State (waiting for launch, in route, lost, crashed, landed, exploring, mining, homeward bound, malfunction)
Location (AUs from Sun)

Destination (target Asteroid identifier)

As resources permit, new spacecraft can be added. Existing spacecraft can be listed, and also looked up by id. Updates to spacecraft can be saved.
All spacecraft management methods have restricted access.

Mission Management System

The Mission Management System is responsible for creating and launching missions.



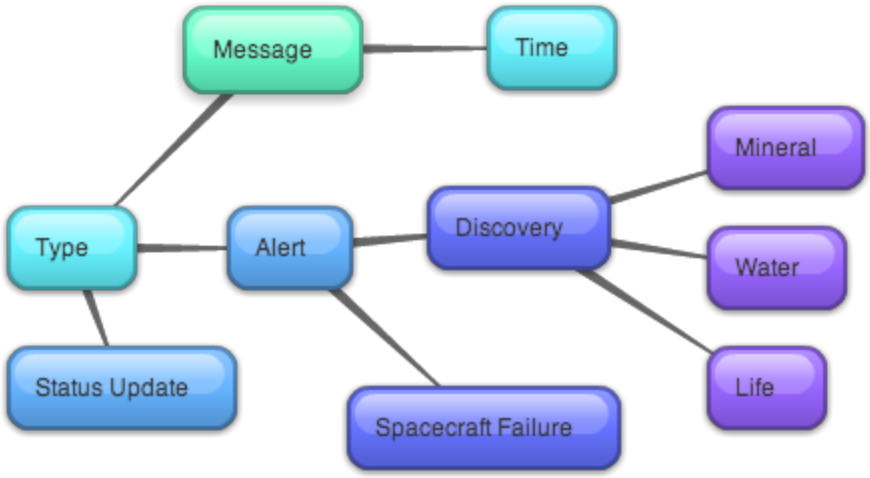
The following mission attributes are required:
unique id for mission
name of mission (e.g. “sling shot”),
purpose of mission (e.g search for water)
spacecraft id of fully provisioned spacecraft that will perform the mission
launch date (start time)
eta, estimated time of arrival
destination: the destination asteroid for the the Mission
status: (waiting for launch, in progress, complete, aborted)

As missions are defined, the available resources should be updated. Resources of fuel, spacecraft, and operating budget should be reduced in accordance with the cost of each new mission.

Mission Management must maintain status of the land-based communication links, and also the automated control system. Each system must have a current status and be able to alert the Mission Control Center of any failures.

Mission Management is also responsible for receiving messages from the spacecraft. As messages are received, the message content should be parsed and understood. The status of the robots should be updated appropriately. Also, if a discovery is reported by a spacecraft, the

associated asteroid should be updated. For example, if water is discovered on Ceres, then the Ceres asteroid should be updated to reflect that it contains water.



Messages must be defined in sufficient detail to identify the spacecraft sending the message, the type of message, with required details to update the spacecraft status, and possibly the target Asteroid in case of a discovery. Mission Status should be updated appropriately though the life cycle of the mission. For example, if a spacecraft accidently crashes into rather than lands on the target asteroid, the spacecraft status should be set to “crashed” and the mission status should be set to “aborted”.

All mission management method interfaces have restricted access.

Command and Control User Interface

A Command and Control User Interface will provide a human friendly graphical user interface (GUI) for:

- logging in and out
- define missions
- monitoring and updating mission status
- monitoring and updating spacecraft status
- monitoring and updating asteroid status
- monitoring Mission Control resources (fuel, number of available spacecraft, operating budget)
- monitoring status of the ground based communication links and the automated control system.
- Monitoring incoming messages from the spacecraft

The Command and Control User Interfaces should leverage the service interfaces of the

- Asteroid Inventory System
- Robotic Spacecraft Management System
- Mission Management System
- Authentication Service

Assumptions:

You should reuse the Authentication Service that you designed and implemented in your assignment 4 solution. You do not need to include the design for the Authentication Service, but you should reference the interface where appropriate. Augment the restricted access service interfaces to accept an access token.

References:

Asteroid Mining:

How Stuff Works:
http://science.howstuffworks.com/asteroid-mining.htm
Wikipedia:
http://en.wikipedia.org/wiki/Asteroid_mining

Planetary Resources (commercial enterprise to mine the asteroids)
http://en.wikipedia.org/wiki/Planetary_Resources
http://www.planetaryresources.com/mission/

Dawn Spacecraft exploring Vesta and Ceres.
http://dawn.jpl.nasa.gov/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