Blackboard Architecture Style

Group Name: Use your Imagination
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Description: What is it?

The Blackboard is a behavioural pattern that allows several components to coordinate and work together to build up solutions to non deterministic models. The blackboard acts as a global information store where the other components can read and write to. The blackboard pattern is analogous to working on a whiteboard with coworkers to solve a problem.

Structure and Components

- Blackboard
    - The shared global state that contains objects from the solution space. The blackboard manages central data and updates the knowledge sources. This allows multiple components to use the blackboard to communicate their solutions between each other.
    - An abstraction of the solution that is at a high enough level to allow the knowledge sources to contribute to a partial or complete solution without requiring to know the specific context of the problem.
- Controller
    - The control component monitors the blackboard and moderates the knowledge sources. The control component schedules the individual knowledge sources. As new partial solutions are reached, the controller will schedule new knowledge sources to modify the Blackboard on their own.
- Multiple Knowledge Sources
    - Specialized workers that have their own representation of the problem and blackboard. Each instance has expertise in its own field. The Knowledge sources create their own evaluations, compute results and updates the blackboard with their results. The only communicate through the blackboard.

Advantages

- When there exists enough diverse sources of input and knowledge, allows for efficient managing of resources across a distributed network.
- Allows for efficient scheduling of tasks and modular design
- Good when problems can be broken down into subproblems

Disadvantages

- Controller can become extremely complex to make the best use of available knowledge sources, which can lead to errors or delays if implemented incorrectly.
- Difficult to breakdown problem into subcomponents to be worked on
- Most software engineering is modular and enclosed, Blackboard tries to share everything
- Everything is shared and can introduce side effects

Example

- ***Problem***: Getting to Mars
- ***Knowledge Sources (Agents)***:
    - Aeronautic Engineers
    - Psychologists
    - Doctors
    - Physicists
    - Astronauts
    - Investors
    - Managers
- The problem cannot be solved by any one individual agent, and each one has their own individual specialty that applies to a given part of solving the problem and reaching the solution.
- ***Partial Solutions***:
    - Acquiring the money to fund the project (Investors)
    - Surviving in space for as long as it would take to get to Mars (Doctors, Psychologists)
    - Building a spaceship that can reach Mars (Engineers)
    - A crew that can handle the trip and pilot the ship (Astronauts)
    - Planning the trip and making the navigation calculations (Physicists)
    - Planning reentry and launch on Mars (another team of Physicists)
    - Building the Mars Lander (another team of Engineers)
- ***Controller***: As partial solutions are reached, decide which knowledge sources to assign to a given part of the problem to reach new partial solutions, eventually combining them together to form a complete solution (Managers).
- ***Complete Solution***: A team of astronauts reaches Mars, lands, takes-off, and is able to return to Earth, alive and in good health.

Non-functional properties

The blackboard model provides effective solutions to the design and implementation of complex systems where heterogeneous modules must be dynamically combined in order to create a solution that solves the problem. This also allows the blackboard model to have important non-functional properties such as:

- Reusability: Knowledge sources are independent specialist that can be reused in different projects. Reuse is made easier by the fact that there is no direct communication between knowledge sources.
- Changeability and maintainability: High level of modularization and clear separation between control and domain makes maintenance phase easier.
- Robustness: The model naturally leads to the definition of alternative knowledge sources to solve a given sub-problem

Real-world applications

- The RADARSAT-1,[5] an Earth observation satellite developed by Canada to monitor environmental changes and Earth's natural resources.
- CAD software was developed in the early 90s using a set of rules and neural networks as specialists operating on a blackboard system.
- Adobe Acrobat Capture (now discontinued) used a Blackboard system to decompose and recognize image pages to understand the objects, text, and fonts on the page.

Visual Representation

Problem: We want to get a team of astronauts to Mars.

Description: Several members from the audience will come to the blackboard, each of them will be assigned a role, and called upon to answer a subproblem based off their own knowledge to getting to Mars. Combining all the subproblems and answers will solve to the overall problem

Problem: We want to get a team of astronauts to Mars.

Participants:

- Finance
- Personnel
- Engineer

Partial solutions:

- How are we going to raise the money to go to Mars? (Finance)
- Who will be going to Mars? (Personnel)
- What is the ship going to look like? (Engineer)

Cards:

FINANCE

PERSONNEL

ENGINEER

Sources

- http://users.encs.concordia.ca/~gregb/home/PDF/soen6461_blackboard_arch.pdf
- http://hillside.net/plop/plop97/Proceedings/lalanda.pdf
- https://en.wikipedia.org/wiki/Blackboard_(design_pattern)