

Patterns

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Part I.

Architectural Patterns

1. Pipes and Filters

2. Blackboard

3. Broker

4. Presentation-Abstraction-Control

4.1. Example: Information system for political elections

The top-level agents abstraction component provides an interface to the data repository, reads, writes and operates on the collected data. The control component organizes communication and cooperation with the intermediate agents. This top-level agent does not have a presentation component. There is only one intermediate agent in this example, the view coordinator. Its abstraction component maintains data about all currently active views. Its control component mainly controls and organizes all subordinate agents. It can also create and delete subordinate agents. The presentation component provides a palette of different views from which users can choose one. The bottom-level agents control component is responsible for communication with the view coordinator (intermediate agent). Its abstraction component saves the presented data and maintains chart-specific information. The presentation component is responsible for the displaying of the specific chart and providing all functions to be applied on it.

4.2. Context

PAC is especially used for developing interactive software. The hierarchical structure of PAC suits multi-user applications well. Systems that experience much replacement, expansion and/or removal of software components also benefit from the architecture's dynamic design.

4.3. Problem

In interactive systems multiple agents work at the same time on separate parts of the same project (horizontal decomposition). Also, some agents work closer with the database and some of them closer with the users (vertical decomposition).

4.4. Solution

The solution consists of handling relations between multiple PAC agents in a tree-like hierarchy. First of all, every PAC agent is divided into three different components: Presentation, abstraction and control. The presentation component displays the data to users, while the abstraction component handles the data model and carries out functional operations on it. The control component primary connects the presentation and

4. Presentation-Abstraction-Control

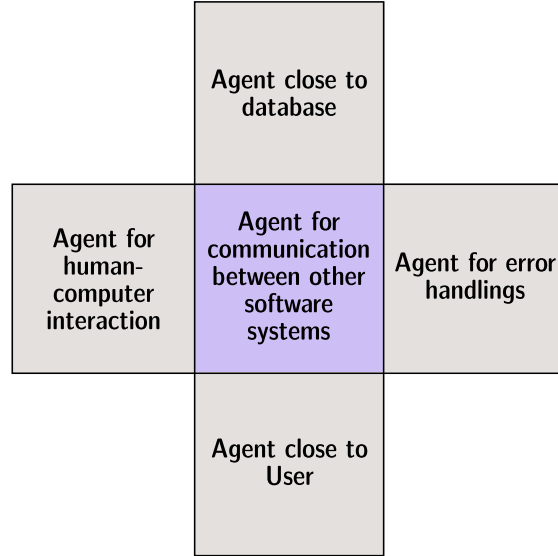


Figure 4.1.: The Problem¹

abstraction components and furthermore allows the communication between its own and other PAC clients.

Now the goal is, to create a structure of multiple PAC agents as the following. There should be one top-level agent representing the functional core of the whole application, on which most of all the other agents are depending. As this is the root of our tree, the leaves are called bottom-level agents. These stand for the interactive part of the system, so users only operate on them. Now intermediate-level agents are the connection between the functional core and the interactive part of the application. With these, relationships between and combinations of lower-level agents are represented.

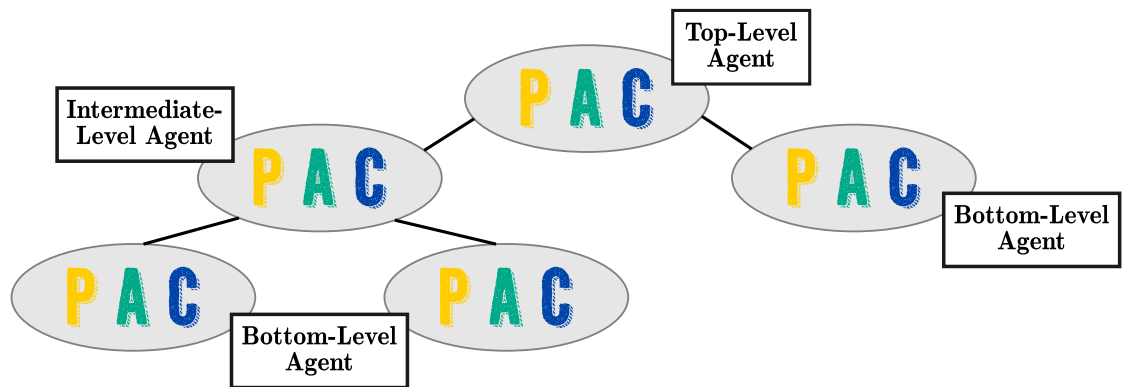


Figure 4.2.: The structure is the solution

4.5. Structure

To provide the functionality of interactive software systems it is structured as a tree-like hierarchy of PAC agents. There are three types of agents (top-level agent, bottom-level agent and intermediate agent), so every agent is responsible for a specific aspect of the applications functionality (cf. Buschmann et al., Pattern-orientated software architecture: page 146). Agents have three responsibilities: presentation (graphical user interface), abstract (data model) and control (communication and mediation between agents).

4.5.1. Top-Level Agent

The top-level agent is unique in the system. He accepts all global responsibilities, such as the database and parts of the user input interfaces, that cannot be assigned to specific subtasks (cf. Buschmann et al., Pattern-orientated software architecture: page 147).

The abstraction component of the top-level agent is the interface to all information about the data model. This includes to manipulate and retrieve information about the data model. The presentation component of the top-level agent has none, until only a few responsibilities. The bottom-level agents resume the presentation.

The control component consists of three subcomponents. First, top-level agents allow access to data model for lower-level agents. Second is the coordination of all PAC agents, to ensure correct collaboration and data exchange (cf. Buschmann et al., Pattern-orientated software architecture: page 149). Last, a subcomponent is to collect information about interaction between user and system. The top-level agent checks, if a user request can be performed by data model and documents history of operations done on the functional core.

4.5.2. Bottom-Level Agent

Bottom-level agents represent one specific object belonging to the application. The presentation component presents a specific view on the object and provides access to functions the user shall be able to use on the object. It also maintains information about the object. The abstraction component is similar to the abstraction component of the top-level agent: it maintains agent-specific data, but no other agent depends on it. The control component manages the relation of presentation component and the abstraction component, serving as an adapter. It is also responsible for communication to intermediate agents, passing outgoing events and messages to the associated higher agents control component and passing incoming events to the presentation component and incoming data to the abstraction component. Bottom-level agents can also provide system services.

4.5.3. Intermediate-Level Agent

The intermediate-level PAC agent is responsible for composition and coordination. The agent has to define new abstraction. The other job of the intermediate-level agent is to

4. Presentation-Abstraction-Control

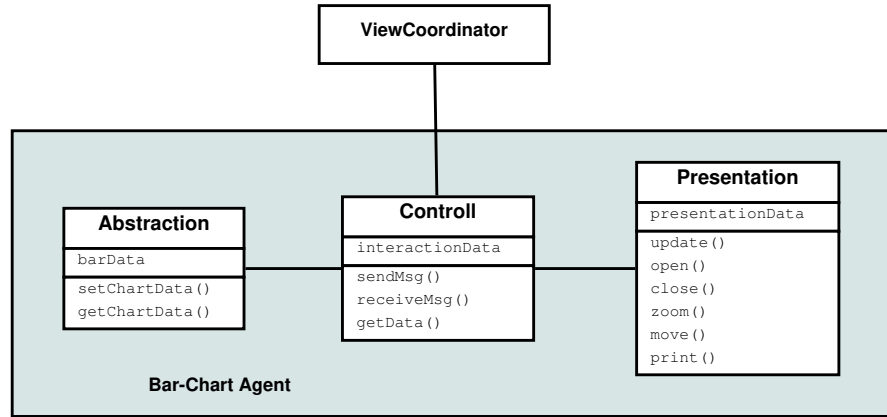


Figure 4.3.: Components¹

manage consistency steadiness between the different lower-level agents.

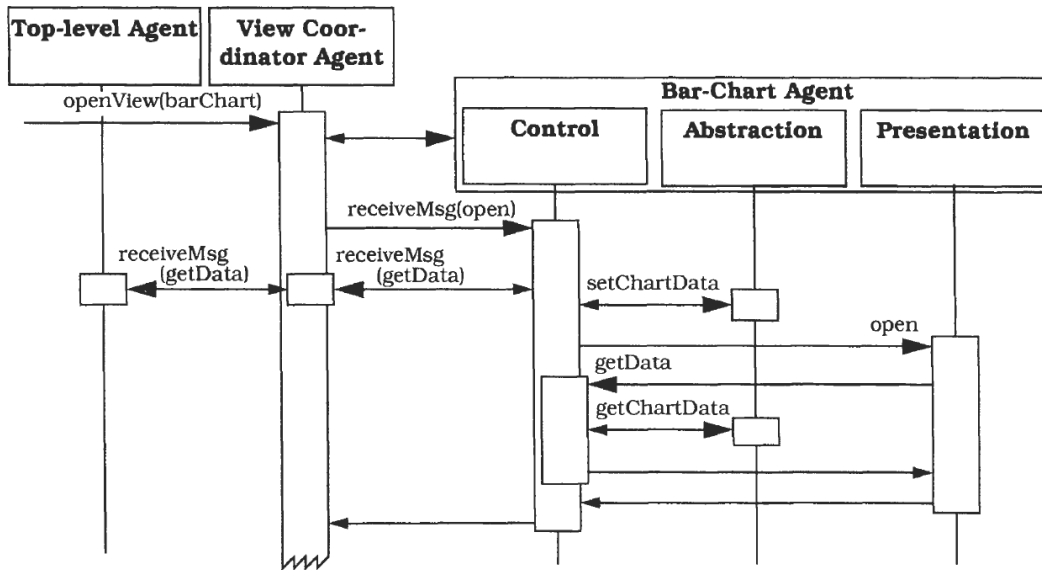
The abstract component manages the data of the intermediate-level PAC agent. The user interface is implemented by the presentation component. The control component communicates with top-level and bottom-level agents.

In the information system for political elections we need one intermediate-level agent. The presentation component of the agents creates a tool to view the election data for example in bar or pie charts. The abstraction component is responsible for all currently active views. Each view is created by one bottom-level agent. The control component must control all subordinate agents. The intermediate-level agent informs the bottom-level agent about changes made by the top-level agent. The intermediate-level agent creates and deflects bottom-level agents on user request.

4.6. Dynamics

Now we will take a deeper look at the internal functions of PAC, analysing two scenarios. In the first one (Fig. 4.4) we describe what will happen, if a new bar-chart view of the election data is opened. First a query is send to the presentation component of the view coordinator to open a new bar chart. Then the control of the view coordinator starts the required bar-chart agent. That means the view coordinator sends an open event to the control component of the bar chart agent. At next the control component of the bar chart gets the data from the top-level agent and saves it in the abstraction component. After the process is finished the control component can enable the presentation component to display the chart. At last the presentation component displays a new window with the retrieved data from its belonging abstraction component.

In the second scenario (Fig. 4.5) we have entered new election data in the system. At first the new data is entered in a spreadsheet and the control component of the spreadsheet agent sends it to the top-level agent. After receiving the spreadsheet the

Figure 4.4.: Dynamics: first scenario¹

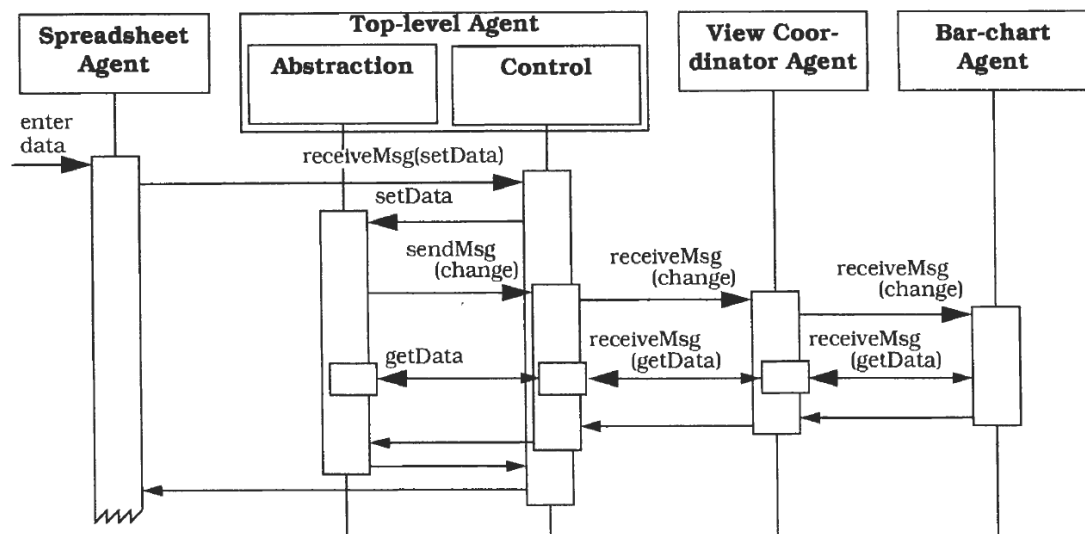
top-level abstraction is requested to change the repository. Then the top-level control component is asked to update all belonging agents with the new data. Therefore we need the view coordinator agent. The view coordinator sends to all view agents a change notification. Now all low-level Agents update their data.

4.7. Known Uses

4.7.1. Network Traffic Management

In regular intervals monitored switching units send their traffic data to a control point where the data gets stored, statistically evaluated and analyzed, and displayed. The data is used to identify problems in the traffic at which point the system can be used to improve it by changing the networks parameters it displays. The system is also responsible for handling network exceptions that might occur.

Every single function of the system is represented by its own bottom-level PAC agent. Further PAC agents are used for each view of the network, the jobs it can perform, and the additional services it offers (e.g. Mail). Those three categories -view, jobs and additional services- have their own intermediate-level agent that coordinates their respective bottom-level agents. A fourth intermediate-level agent organizes user sessions. The top-level agent coordinates individual user sessions, and is the only agent to communicate with the system's functional core. The core is implemented separately from the agent hierarchy. The hierarchy of the system is dynamic. Should, for example, a user start a new session, a corresponding agent is created. At the end of the session the agent gets deleted.

Figure 4.5.: Dynamics: second scenario¹

4.7.2. Mobile Root

The system's purpose is to allow interaction between an operator (user) and a mobile robot. Its mission can be specified by the operator using this system. The system keeps track of the mission's progress at any time. The robot navigates itself through a room that can contain walls, equipment and moving obstacles like people. It does so by using information it receives from both the operator and its built-in sensors.

Every wall, route and place is represented by its own bottom-level agent. Together they visualize an environment which, in turn, is represented by an 'environment' PAC agent. This agent is at the intermediate level of the hierarchy. These agents control their corresponding bottom-level agents. The operator can exert control in form of a 'palette' PAC agent that gets implemented, another bottom-level agent. Together, a palette and an environment agent form a workplace. Naturally, such a workplace has its own agent, also at the intermediate level. Multiple views of the same environment are handled by a multi-workspace PAC agents. The top-level agent includes the functional core of the application, which is a rule-based supervisor that navigates the robot.

Notes

¹Buschmann, F., Meunier, R., Rohnert, H., Sommerlad, P., Stal, M.: Pattern-Oriented Software Architecture, A System of Patterns; Wiley 1996

5. Microkernel

6. Reflection