New distributed sensor system for air pollution monitoring

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ABSTRACT

This paper presents a new method to obtain a control system for air pollution environments that partitions tasks using a negotiation protocol. We analyze the air pollution problems for tailoring our general model to these domains. This system supports collaborative tasks among a number of control nodes possibly distributed in different locations.

PROBLEM DESCRIPTION

Computers are often used for the storage of air pollution information, such as environment data, contamination reports, graphics, time records, ... A convenient form for a unit of this air pollution information is a document. However, the information stored in air pollution documents in multiple sensor-node environments is difficult to utilize for several reasons, for example:

1- The air pollution data are changing dynamically with time.

2- Several contamination isolated informations can mean different things from a global point of view.

A good solution consist of the possibility of consulting every moment all the air pollution data and consider globally several isolated
contamination information using a distributed sensors system for air pollution monitoring.

Thus, in real systems from this category is very important incorporate two elements of distributed problem solving namely task-sharing and result-sharing. Also a good design of an inter-control and data capture nodes protocol is a key aspect to get efficient monitoring systems. In that sense this paper presents an innovative design solution for multiple sensor nodes in the task of cooperative problem solving.

NETWORK ARCHITECTURE

Our sensors network models transfer of control in a distributed system with the approach of negotiation among autonomous intelligent beings. The sensor network consists of a set of nodes that negotiate with one another through a set of messages. Nodes represent the distributed computing resources to be managed. In any given transaction, three classes of nodes may be identified:

![Network Architecture Diagram]

- **Manager nodes** are nodes that identify a task to be done and assigns it to other nodes for execution.
- **Open Atmos. + Air Contamts + Meteorolog. Data**

Figure 1. General Architecture.
b) Agent nodes are nodes that offer to perform a task. Winner node is a successful agent, one whose bid has been accepted by the manager.

c) Sensor nodes are base nodes because they capture pollution information signals from the external environment (figure 1).

DISTRIBUTED SENSORS SYSTEM

Our distributed sensors system may be used in air pollution control. Individual nodes are able to carry out one or more specific tasks. Signal collectors (agent nodes) get information that they need from sensor nodes, and evaluate them on sensory capabilities as well as geographical location.

![Diagram](Advanced Sensor Node)

Type-1 of pollution

(1) + (3)

Dual Information

Type-n of pollution

(2) + (3)

(1) E.g. Steel Dust, SO₂, NOₓ, ...
(2) E.g. CO₂, CO, Dioxine, ...
(3) E.g. Date, Time, Weather Temperature, Humidity, Atmospheric Pressure, Radiation Level, Gravitational/Magnetic/Electric Fields, Ozone Level,...

Figure 2. Generalized Sensor-Node Structure

A manager node responsible for monitoring a local area solicits bids from agent nodes that can integrate information from sensors, and evaluates bids on the basis of the geographical location of the agents. An area manager, confronted with sensory information, invites bids from contamination managers to find which one is best suited to manage the sensed object.

There are several important features of this system:

a) The system interfaces with the real world through nodes that have sensory capabilities.
These bottom level nodes are distinct from the other nodes in the system, since only the sensor nodes can directly see the real world (figure 2).

b) Because of the diversity of tasks to be performed, the parameters on which bids are selected differ depending on the task, and are specified by the manager when announcing a task.

c) Both the negotiation process and the task being allocated are computational in nature.

The environment is the ultimate source of the system's inputs and the destination of its results. Our model needs to include knowledge about the rate at which its inputs will arrive from the real world and the variability of that rate, the characteristics of those inputs and their variability, interactions or correlations between inputs, the effects of outputs on inputs, and the degree to which it is ignorant of any of these things.

COMMUNICATION MODEL

It is useful to model a monitoring network with a formalism for concurrent processing:

1) Each node is a state machine (figure 3) communicating with other nodes over bidirectional channels, each connecting exactly two nodes. (The channel is a modeling tool, not an implementation specification. The model represents the net as having point to point connections, even though most implementations will use a bus-like organization.)

![Figure 3. Nodes' State Machine.](image-url)
2) Each channel has an alphabet, consisting of the repertoire of messages that can travel over it.

3) The alphabet of a node is the union of the alphabets of all channels over which it communicates.

This formalism allows us to characterize the nodes in the distributed sensor system for air pollution monitoring by the set of messages in their alphabets. Mainly, those messages are of three types:

(a) Those sent by the manager of a task (task announcements, awards and terminations).

(b) Those sent by the agents for a task (node availability announcements and bids).

(c) Those sent by the winner for a task (node availability announcements, bids, acknowledgments and reports).

A deeper analysis of the real messages interchange will be the next description:

-1- A manager issues a 'task announcement' describing the task to be done and the criteria for bids.

-2- Agents send 'bids' to announce their willingness and ability to perform a task.

-3- The 'award' message from the manager to the successful agent establishes that agent as the winner for the task.

-4- The winner sends an 'acknowledgment' of the award, either accepting or rejecting it.

-5- The winner sends 'reports' to the manager announcing status or termination of a task.

-6- The manager may send a 'termination' to a winner to interrupt its performance of a contract prematurely.

-7- Idles nodes may broadcast their availability with a 'node availability announcement'.
In our communication model, we can distinguish the same three above types of nodes: manager, agent and sensor node. The manager node can manage tasks but not perform them. The alphabet of its output channels includes the manager messages and the alphabet of its input channels includes the winner messages. The winner can perform tasks but not manage them. The alphabet of its input channels includes the manager messages while the alphabet of its output channels includes the winner messages.

The communication model is a prediction of what the monitoring environment will be like when the node organization is functioning within it.

CONCLUSIONS

Our monitoring network is a useful architecture for the distributed control of air pollution environments. The use of negotiation accommodates the stochasticity inherent in monitoring.

We have suggested that descriptions of organizational node structures are important for the instantiation and maintenance of distributed sensor systems over large air pollution sensor network. We have identified three types of control nodes and have used them to describe and instantiate arbitrary complex organizational relations into the whole monitoring system.

The system described here demonstrates that with the present state of the art, advanced protocol techniques can be implemented for solving complex tasks in environmental applications.

Our present researches are based on a continuous evolution of this work on developments about ways to combine information from a global scheduling process with the local adaptability provided by negotiation.
REFERENCES


