Contract Net Protocol

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Outline

- ◆ What is Contract Net Protocol
- ◆ FIPA Standards
- ◆ Step-by-Step Example
- ◆ Existing Systems
- ◆ Demo
- ◆ Shortcomings
- ◆ Future Plans and Goals

Imagine…

Contract Net Protocol (CNP)

- Originally proposed by Smith (1980)
- Fully automated negotiation
  - Distributed problem solving
  - Electronic marketplace for buying and selling of goods
- Two types of agents **Initiator** and **Participant**
- At any time, any one agent can be an Initiator, Participant or both
- Allows contracting as well as subcontracting

CNP - Sequence of Steps

1. Initiator sends out a Call for Proposals (CFP)
2. Each Participant reviews CFP's and bids on feasible ones
3. Initiator chooses the best bid and awards a contract to that Participant
4. Initiator rejects other bids

FIPA Standards

- Stands for Foundation for Intelligent Physical Agents

- Contract Net Interaction Protocol Specification

- Makes use of Communicative Act Library Specification
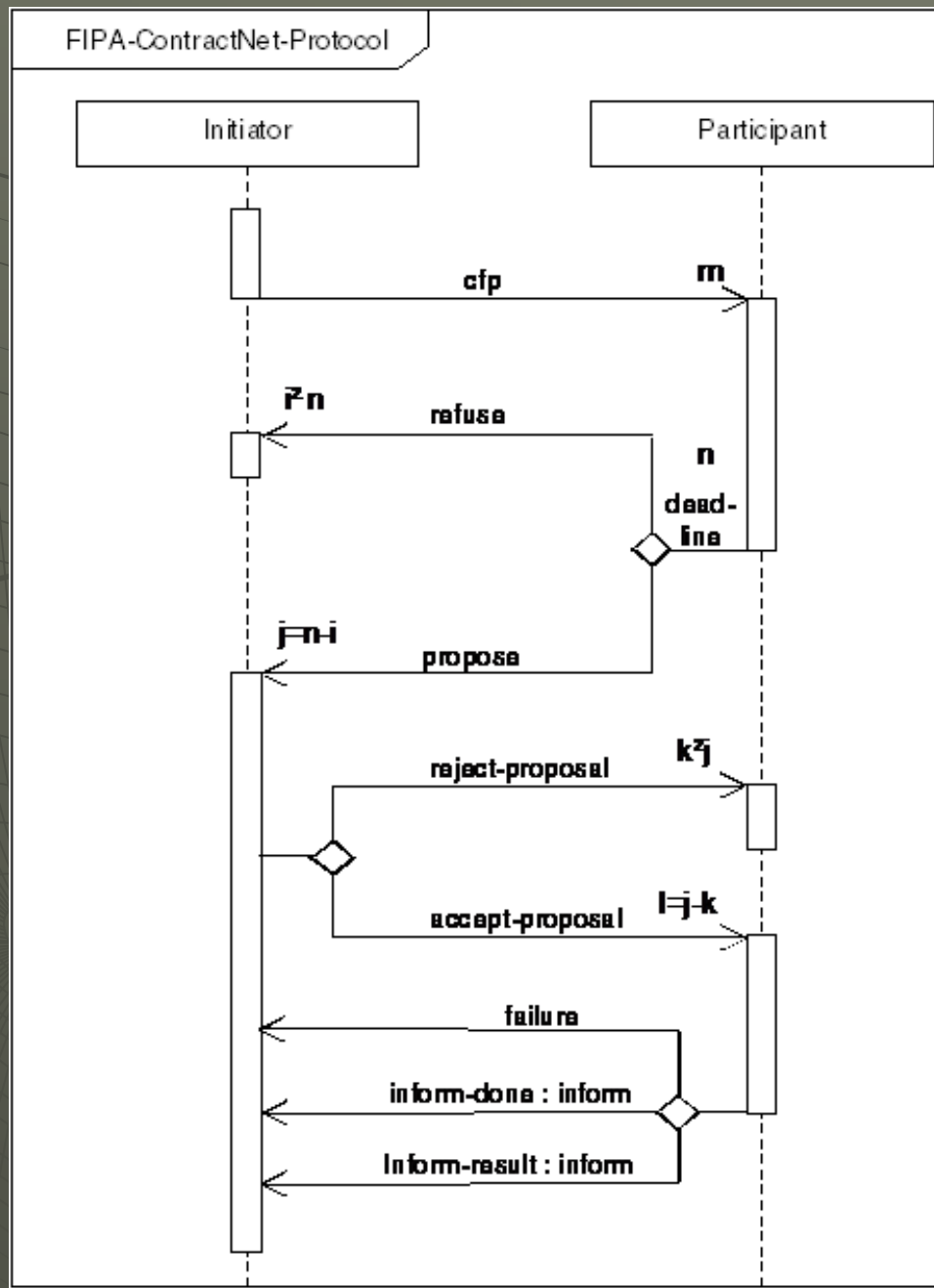
Step-by-Step Example

◆ 1 Initiator
- Wants 100 units of commodity A
- Maximum price of 5.00 price units/unit of A
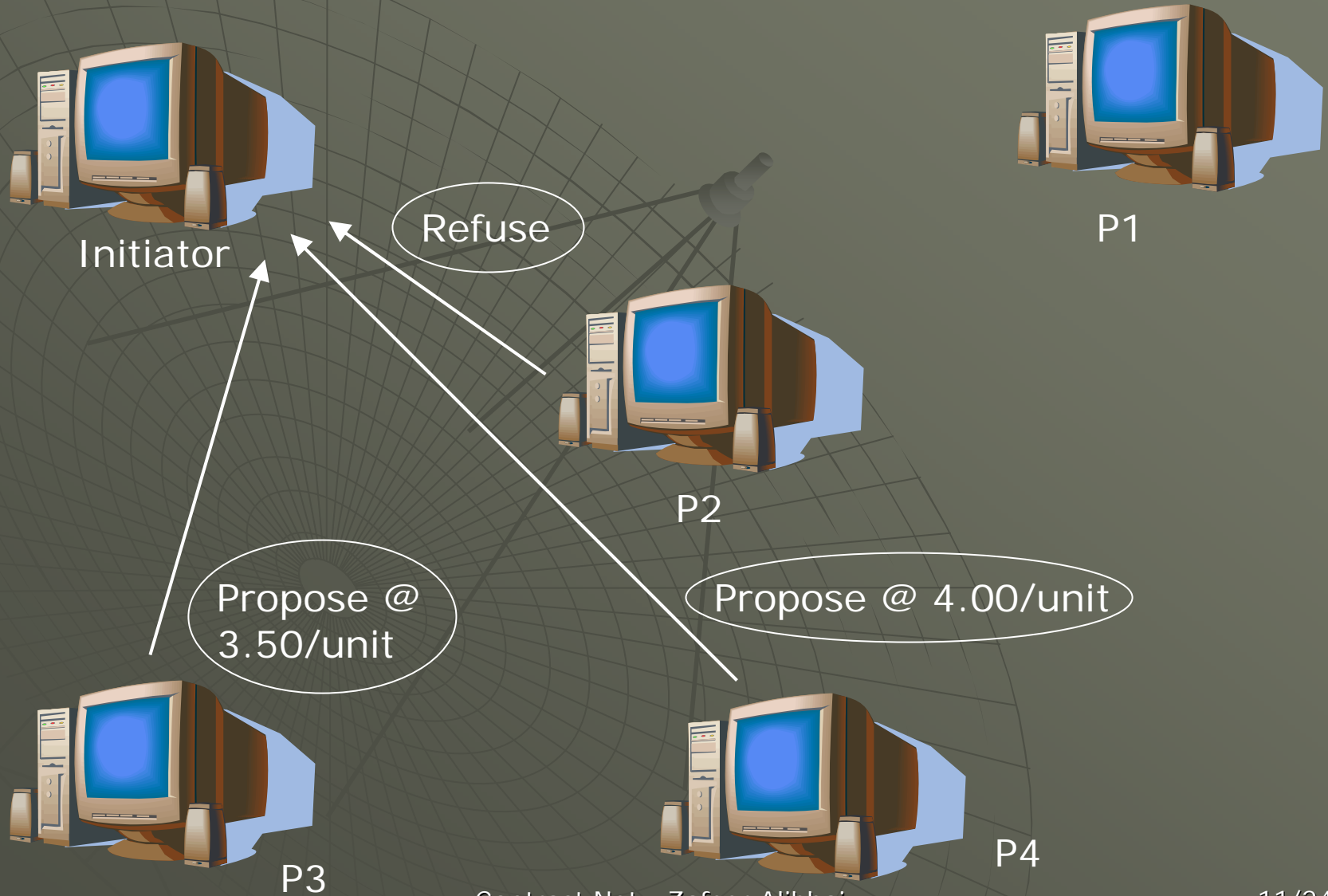- Delivery time of 2:00 PM est

◆ 4 Participants

Initiator Sends Out CFP

CFP

Initiator

P1

P2

P3

P4
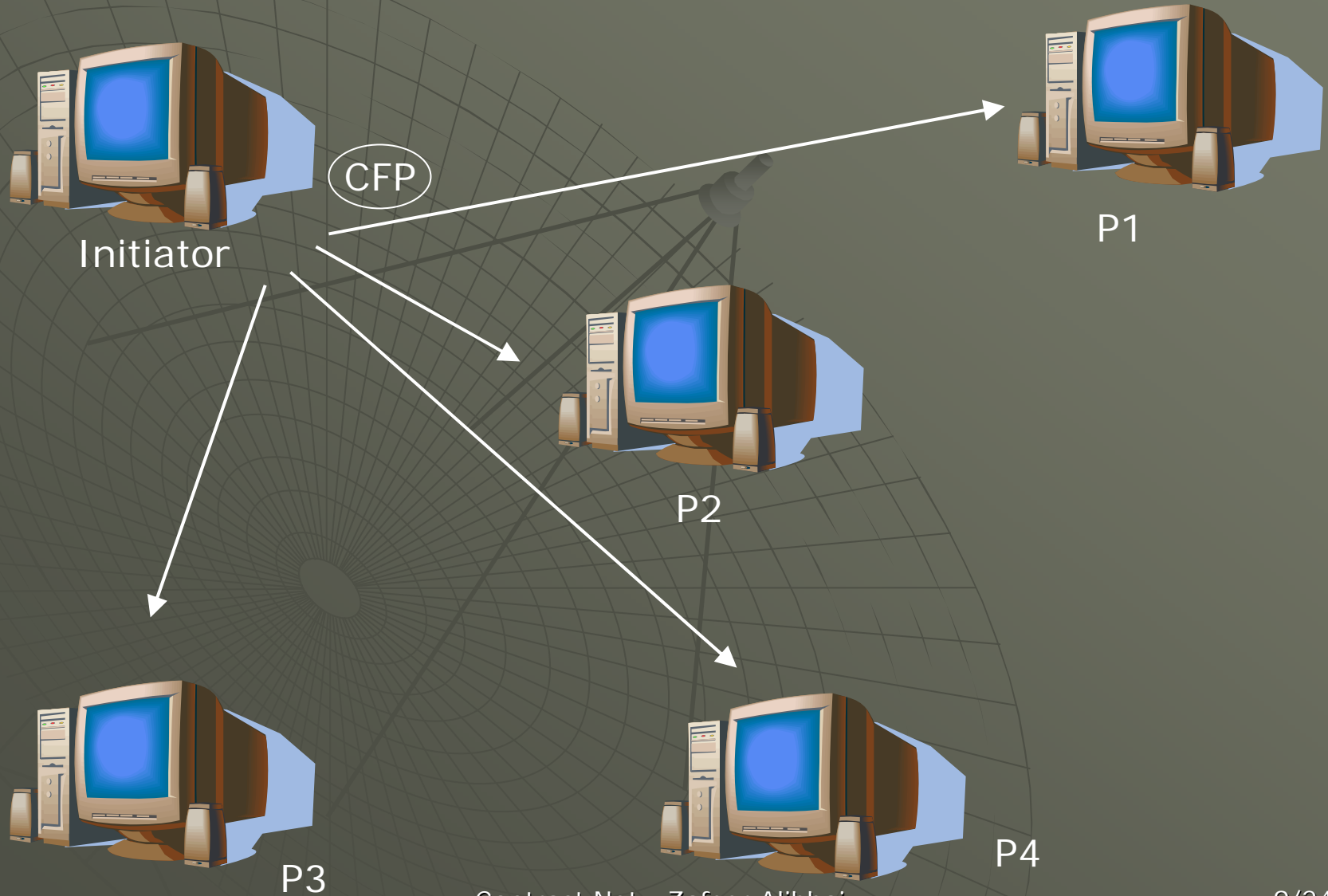
Participant Response to CFP

- P1 – No Response
- P2 – Refuse
- P3 – Propose @ 3.50/unit
- P4 – Propose @ 4.00/unit

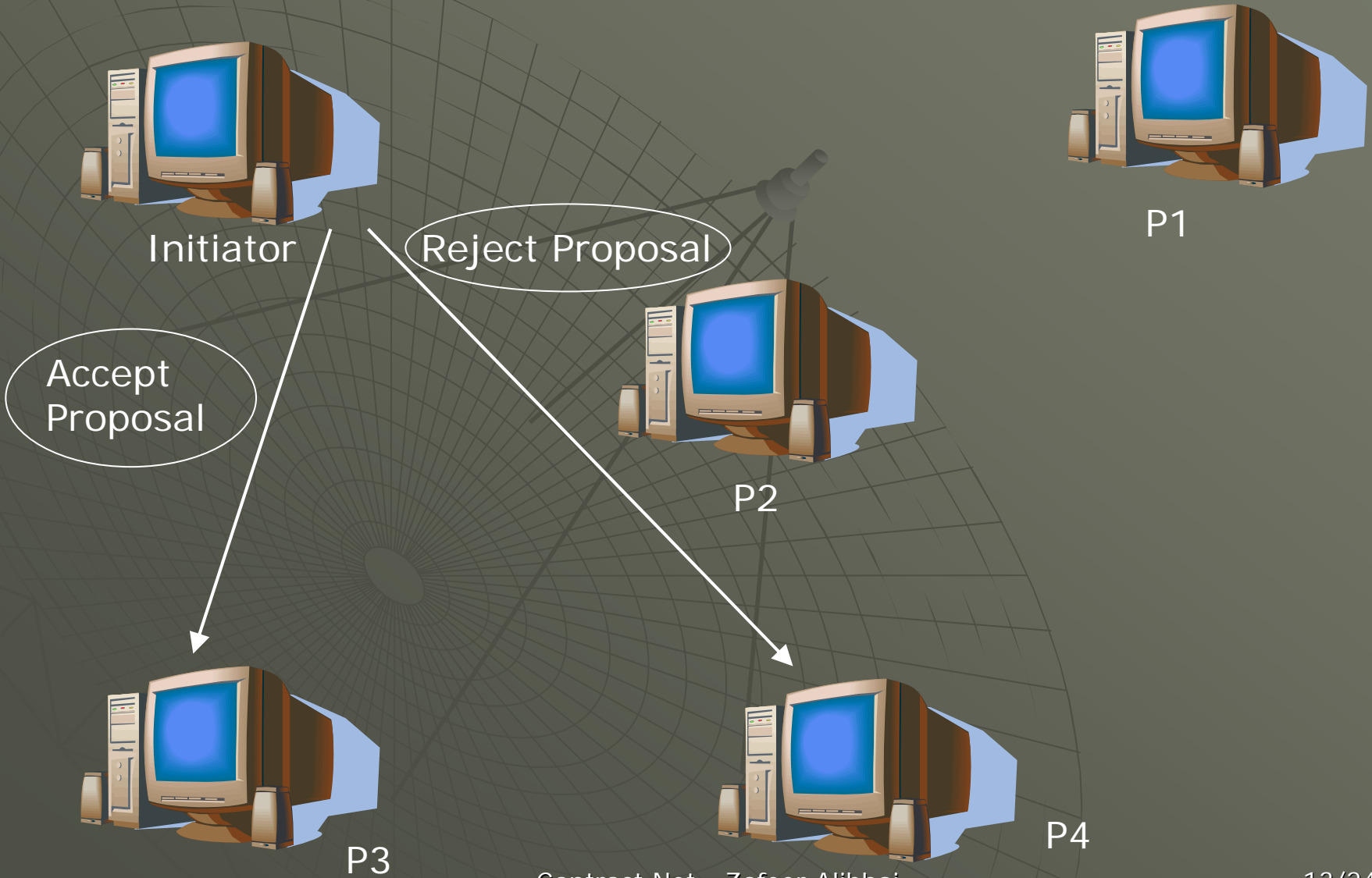# Deadline Passes

Refuse

P1

Initiator

P2

Propose @ 3.50/unit

Propose @ 4.00/unit

P3

P4

Initiator Response to Proposals

- Find the Lowest cost in price units
  - $\rightarrow$ P3 < P4
- Accept P3's proposal
- Reject P4's proposal

Deadline Passes
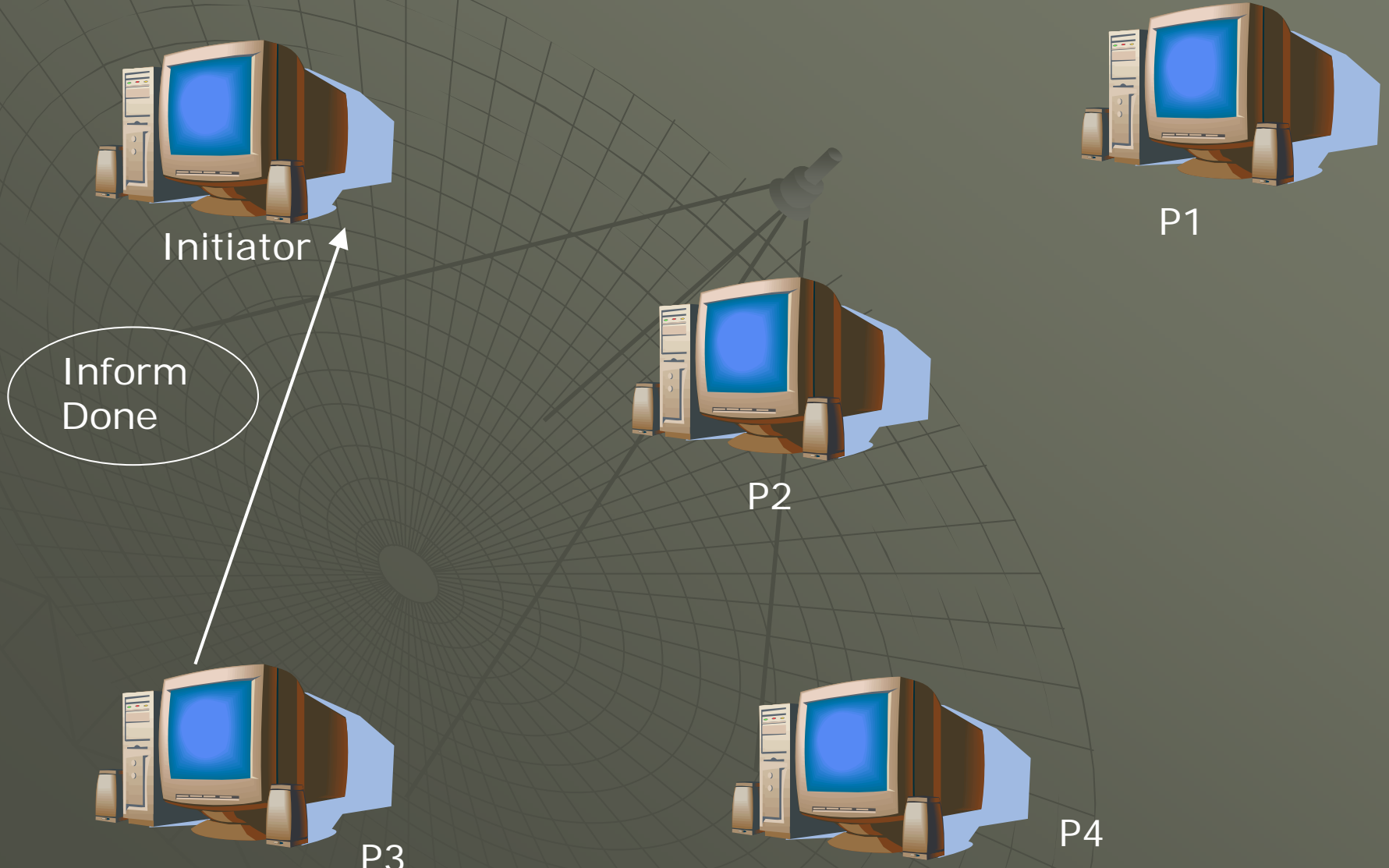
Initiator

Reject Proposal

Accept
Proposal

P1

P2

P3

P4

Contract Established

- ◆ **Contract between Initiator and P3**
  - 100 units of A
  - 3.50 price units/unit A
  - Delivery time of 2:00 PM est
- ◆ **One final message**

After Delivery at 2:00 Pm est

Initiator

Inform Done

P1

P2

P3

P4

Existing Systems

- TRACONET @ U of Massachusetts
- Aircraft Coordination @ Honeywell
- INTERRAP
- MadKit

TRACONET

- Automated delivery truck routing
- Simulation has two companies
  - A with 3 dispatch centers
  - B with 2 dispatch centers
- Significant savings over local solution using heuristic parallel insertion algorithm

TRACONET

Dispatch center	Deliveries	Vehicles	Average delivery length	Cost savings in 15 minutes	Cost savings in 30 minutes
A1	65	10	121 km	5%	6%
A2	200	13	169 km	12%	18%
A3	82	21	44 km	31%	34%
B1	124	18	145 km	11%	23%
B2	300	15	270 km	9%	15%
Total	771	77	187 km	11%	17%

Honeywell

- Coordinate aircraft mission and defense
- Contract net used for task assignment to highest bidder
- Negotiation before and during flight

INTERRAP

- ◆ Automated loading dock with miniature robots

- ◆ Use cooperative planning

- ◆ Resolve goal conflicts and allow synchronized actions

MadKit

- ◆ Agent Framework
  - Aides in agent development
- ◆ Simple Contract Net example
- ◆ Simulated Travel Agency

MadKit Demo

Shortcomings

- ◆ Systematic Failures
- ◆ Communications Infrastructure
- ◆ Scheduling (real time or time slices)
- ◆ All agents must be synchronized
- ◆ Time-Bound Framework
- ◆ Integration of agents

Future Plans and Goals

- Create a hybrid Initiator/Participant Agent
- Fulfillment of one contract by multiple agents
- Eliminate central arbiter
  - Any agent can make a request
  - The net will find the solution

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