Mobile Agents and Processes Using Communicating Process Architectures

Their Role in Pervasive Adaptation

Jon KERRIDGE,
Jens-Oliver HASCHKE
and
Kevin CHALMERS

NAPIER UNIVERSITY
EDINBURGH

Overview

- Mobility
- Pervasive Adaptation – an overview
- Process Discovery

CSP based Parallelism - Processes

- A system comprises a network of processes
- The processes work together to solve a problem
- Processes undertake a sequence of operations
- All data is local to a process
- Processes can communicate data
- Processes communicate by means of channels

- A process **cannot** access properties of another process by means of a method call

Mobility - Process

- Process mobility means
  - The code and initial state of a process can be moved from one processor to another, where it can be connected into that processor's infrastructure and executed
  - Classes referred to within the process can also be obtained from the processor from where the process definition was obtained
  - Once a Process has been transferred and instantiated it cannot be moved to another node and can only terminate if the Process itself terminates

Mobility - Agent

- A Mobile Agent is a specialisation of a mobile process
  - It can be transferred to another processor
  - It connects itself to processes already executing
  - It undertakes some action in conjunction with the host process, which modifies the state of the Agent
  - It can then disconnect itself from the host process
  - It can then cause itself to move to another processor, which could be the processor from which it started
  - An agent is a self contained capability that achieves some goal, which when complete, causes the Agent to terminate

Pervasive Adapatation

- According to the EU PerAda Action is manifest by:
  - Networked Societies of Artefacts
  - Evolvable Pervasive Systems
  - Adaptive Software Systems
  - Adaptive Security and Dependability
- Which require
  - Dynamicity of Trust
  - Tiny and Massively Networked devices

Process Discovery

- An exemplar system comprises:
  - A number of TCP/IP networked processors (nodes)
  - A Data Generator node
    - Keeps a record of connected nodes
    - Creates data of defined types, which is
    - Sent randomly to any Processing node that has registered with the network
  - A Processing node,
    - Processes data sent to it by the Data Generator
    - Processed data is then sent to a Gatherer node
  - The Gatherer node
    - Prints out the processed data objects

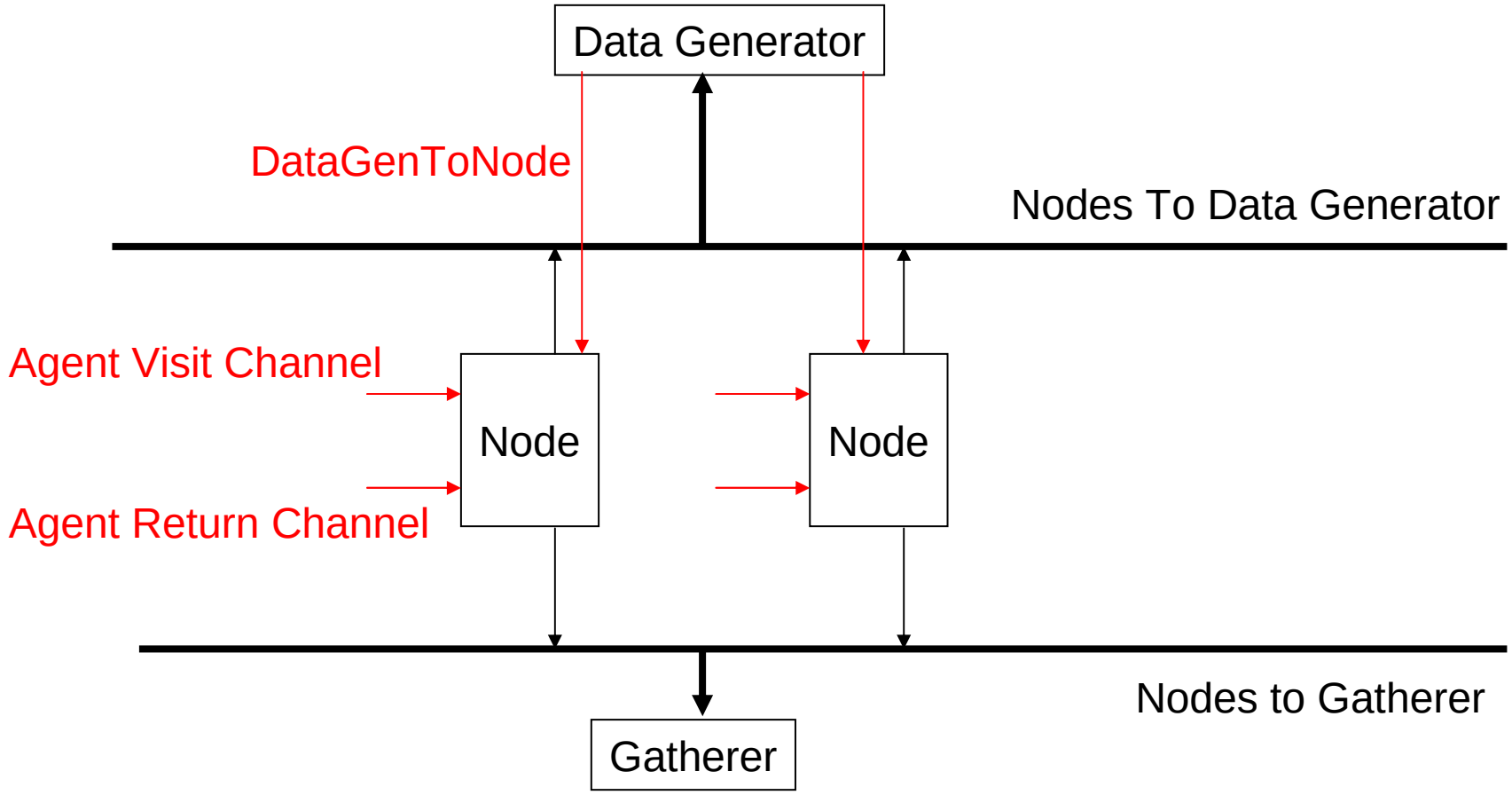
The Challenge

- The processes required to process a data object are guaranteed to be available on the network
- BUT
- Not every Processing node is initialised with an instance of all the required processes
- AND
- Processing Nodes can be added dynamically to the network

So

- When a Processing node receives a data object for which it does not have the required process
  - It sends a Discovery Agent around the network to find an instance of the required process at another node
  - The Discovery Agent returns to the originating node with a copy of the required process
  - The process is transferred to the node where it is instantiated and connected into the Processing node infrastructure
  - The Processing node can now process that type of data

Process Network



Channel an anonymous net channel

Node Processing - Initialising

- Installs any data processes with which it was initialised
- Connects to Data Generator and Gather Nodes
  - By means of named net channels
- Registers itself with the Data Generator sending
  - Agent Visit Channel location
  - DataGenToNode channel location
- Initialises an instance of a Discovery Agent with this node's Agent Return Channel
- Now in a position to accept inputs from the Data Generator process

Node Processing – Running:1

- Input from Data Generator
  - Notification of a new Node
    - Update the agent with the location of the new node's visit channel
    - Remember this in a list of connected nodes
  - Data Object
    - If process available then process the object and send result to Gatherer
    - If process not available; update Discovery Agent and send it on a trip to find the required process

Node Processing – Running:2

- Discovery Agent arrives at Agent Visit Channel
  - Connect Discovery Agent to this Node
  - Discovery Agent sends name of required process to Node
  - Node returns process, if available, or null
  - If process sent then Discovery Agent returns to home node
  - Otherwise Discovery Agent continues visiting nodes
- Discovery Agent arrives at Return Channel
  - Connect Discovery Agent to this (Home) Node
  - Discovery Agent transfer process to home node
  - Home node installs process and is now ready to process data of that type.

Discovery Agent Processing

- Three states
  - Initialising
    - Discovery Agent is pre-loaded with all the Agent Visit Channel locations
    - Discovery Agent is told the name of the required process
    - Discovery Agent then visits nodes to find required process
  - Visiting
    - Discovery Agent connects to the visited node
    - Discovery Agent sends name of required process to node
    - Node sends Discovery Agent either the process or null
    - Discovery Agent continues journey if returned null or home if process loaded
  - Returning
    - Discovery Agent returns to home node and connects to it
    - Transfers process to home node
    - Home node can then install the process

Agent Coding – Properties and Variables

```
class AdaptiveAgent implements MobileAgent, Serializable {

  def ChannelInput fromInitialNode
  def ChannelInput fromVisitedNode
  def ChannelOutput toVisitedNode
  def ChannelOutput toReturnedNode

  def initial = true
  def visiting = false
  def returned = false

  def availableNodes = [ ]
  def requiredProcess = null
  def returnLocation
  def processDefinition = null
  def homeNode
```

Agent Processing – Connect and Disconnect

```
def connect (List c) {
  if (initial) {
    fromInitialNode = c[0]
    returnLocation = c[1]
    homeNode = c[2]
  }
  if (visiting) {
    fromVisitedNode = c[0]
    toVisitedNode = c[1]
  }
  if (returned) {
    toReturnedNode = c[0]
  }
}
def disconnect() {
  fromInitialNode = null
  fromVisitedNode = null
  toVisitedNode = null
  toReturnedNode = null
}
```

Agent Processing - Initialise

```
if (initial) {
    def awaitingTypeName = true
    while (awaitingTypeName) {
        def d = fromInitialNode.read()
        if ( d instanceof List) {
          for ( i in 0 ..< d.size) { availableNodes << d[i] }
         }
        if ( d instanceof String) {
          requiredProcess = d
          awaitingTypeName = false
          initial = false
          visiting = true
          disconnect()
          def nextNodeLocation = availableNodes.pop()
          def nextNodeChannel = NetChannelEnd.createOne2Net(nextNodeLocation)
          nextNodeChannel.write(this)
        }
    }
}
```

Update the list of registered nodes

Initialise Discovery Agent

Send Agent on a trip round nodes

Agent Processing - Visiting

```
if (visiting) {
    toVisitedNode.write(requiredProcess)
    processDefinition = fromVisitedNode.read()
    if ( processDefinition != null ) {
      toVisitedNode.write(homeNode)
      visiting = false
      returned = true
      def nextNodeLocation = returnLocation
      def nextNodeChannel = NetChannelEnd.createOne2Net(nextNodeLocation)
      disconnect()
      nextNodeChannel.write(this)
     }
    else {
      disconnect()
      def nextNodeLocation = availableNodes.pop()
      def nextNodeChannel = NetChannelEnd.createOne2Net(nextNodeLocation)
      nextNodeChannel.write(this)
    }
  }
```

Send name of required Process to Node

If available place copy of process in Agent and return to home node

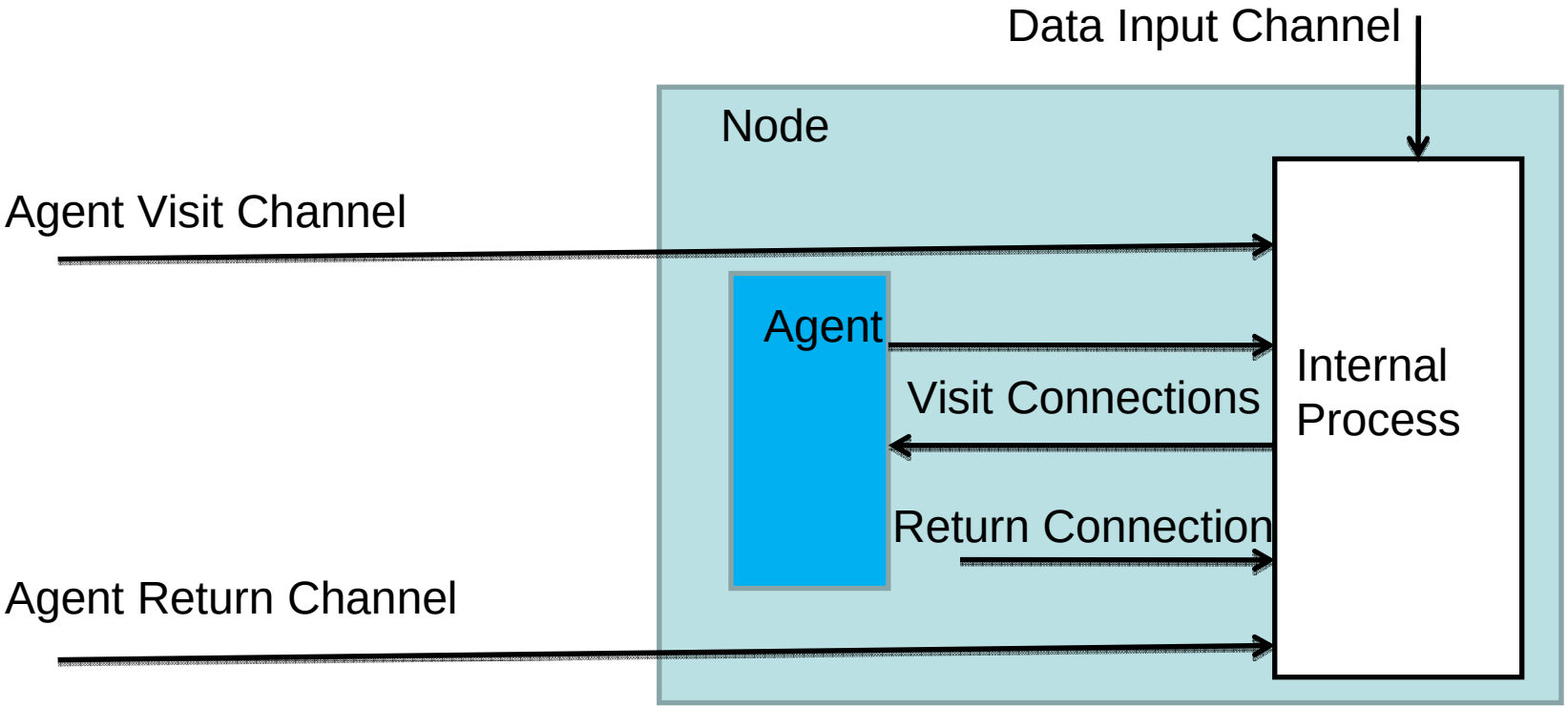
Otherwise, disconnect from node and go to next node on the list of available nodes

Agent Processing - Returning

```
if (returned) {
  toReturnedNode.write([processDefinition, requiredProcess])
}
```

Node Process Internal Architecture

- Node Process provides internal channels which it uses to connect to visiting agents
  - The channels are specific to the type of visiting agent



Node Processing – Visiting Agent

```
def visitingAgent = agentVisitChannel.read()
visitingAgent.connect([NodeToVisitingAgentInEnd, NodeFromVisitingAgentOutEnd])
def visitPM = new ProcessManager(visitingAgent)
visitPM.start()
def typeRequired = NodeFromVisitingAgent.in().read()
```

Connect agent to node and start it. Read name of required process

```
if ( vanillaOrder.contains(typeRequired) ) {
        def i = 0
        def notFound = true
        while (notFound) {
             if (vanillaOrder[i] == typeRequired) {
                  notFound = false
              } else {i = i + 1 }
        }
        NodeToVisitingAgent.out().write(vanillaList[i])
        def agentHome = NodeFromVisitingAgent.in().read()
```

See if required process is available

If so write it to the agent and read in the name of the node requesting it

```
}  else {  // do not have process for this data type
        NodeToVisitingAgent.out().write(null)  }
visitPM.join()
```

Otherwise return a null

Wait for agent to terminate

Mobile Social Network

- People dynamically join a wireless network using a mobile device
- A service is provided that allows ‘friends’ to exchange diary information for the immediate future so they can meet face-to-face.
- An agent is sent from a new arrival to network, with their list of friends and their free times
- Agent finds out which friends are also registered
- Agent finds times when friends are free at same time
  - It then arranges a meeting

continued

- Agent can determine the diary system used by each friend
- Ensures it has correct diary interrogation system bound in
- The Agent can adapt its behaviour as people change their mobile devices and their software infrastrcuture.

Conclusions

- Parallelism enables construction of Agent systems at the Application Layer
- Implemented the Itinerary Agent pattern
- Can move processes from one node to another
- Nodes can adapt their processing as the needs arise

Relationship to Pervasive Adapatation

- Networked Societies of Artefacts
- ~~Evolvable Pervasive Systems~~
- Adaptive Software Systems
- ~~Adaptive Security and Dependability~~