HIC: a Multimodal Adaptive Interaction Platform for Complex Systems

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Human Interaction Container (HIC) paradigm
Interaction Middleware
Interaction Container
Focus on Multimodality Processing
Application to Air Traffic Management
Motivation

The challenge for THALES systems:
Make the move from application-centric to user-centric interfaces

- **Objective:** investigate, develop, experiment and transfer the technology required for the next generation of intelligent user interfaces offering dynamic adaptation to user

- **Solution:** Make the interaction logic explicit and make it independent from other logics (application/business logic and interface/presentation logic)

- **Main issues:**
  - Implement the separation between the various logics
  - Build models for the representation of the interaction context:
    - User (profile, preferences, role, task or mission, …)
    - Domain (application services, application state, business rules, …)
    - Devices (workstation PC, laptop PC, PDA, mobile phone, tablet PC, …)
    - Modalities (graphical, speech-based, gesture-based, …)
  - Propose generic interaction processes that can be easily instantiated upon specific business domains
Human Interaction Container (HIC) Paradigm

**Current Systems**
- Interface
- Processes

**HIC-based Systems**
- Presentation Logic (Business Interface)
- Interaction Logic: HIC (Generic Interaction)
- Application Logic (Business Processes)

**Human Interaction Container Paradigm:**
Decouple the interaction from both the application and the interface
HIC applied to Multi-tier Architectures

Current Architectures

From three tier architectures...

Tier One
Client

Tier Two:
Application Server

Tier Three
Database

HIC-based Architectures

...to four tier architectures

Tier One
Client

Devices

Tier Two
Business Interaction

Tier Three
Application Server

Tier Four
Database

Make Interaction services independent of Terminal specific use

Make Application services independent of Organization specific use

… to four tier architectures
C4I/ISR

For which the challenge is to identify critical information
Technology required:
• Speaker identification
• Language identification
• Audio (speech) filtering
• Topic detection
• Information filtering

Control/Command

For which the challenge is to enhance the realism of interaction
Technology required:
• Speech & natural language processing
• Multimodality
• Engineering for multimodal interfaces

Business Intermediation

For which the challenge is to render collaboration effective
Technology required:
• Timely and accurate data gathering, sharing & dissemination
• Data filtering
• User profile & preference management
• Collaboration support
• Business rule processing

Homeland Security

For which the challenge is to enhance safety of the citizen
Technology required:
• Person identification
• Person and system tracking
• Situation awareness
• Emotion detection

The HIC paradigm impacts THALES domains
where the mission and the environment of the user can be formally described
Architecture of the HIC

Interaction Application (User Container)

Interaction Container (HIC)

Interaction Middleware (HIC)
Interaction Middleware

Adaptor

Interaction Processor

Task Manager

Application

Function Calls & Events

Input Interpreter

Event Logical Forms

Interaction State & History

Interaction Patterns

Business Interaction Patterns

Task Activity

Task Interaction

Output Generator

Event Logical Forms

Data

App. Class Profiles

Application Profiles

Interaction State

Application State

Interaction Patterns

Interaction Tasks

Interaction History

Activity State

Resource Manager

Application Class Profiles

Function Calls & Events
Task Management

- **Why**
  - To plan and control the processing of interaction
  - To ensure interaction consistency

- **How**
  - Using XML representation
  - Using generic task representation and processing technology

- **With**
  - A task model
  - An activity model

```xml
<state id="disconnected">
  <events>
    <event id="connect">
      <in_param id="password" type="java.lang.String"/>
      <interaction_call id="connect">
        <method id="arc.processing.business.handler.Connect"/>
        <next_states>
          <positive>
            <out_param id="flight_list" type="arc.business.FlightList"/>
            <next_state id="connected"/>
          </positive>
          <negative>
            <out_param id="connection_refused" type="java.lang.String"/>
            <next_state id="disconnected"/>
          </negative>
        </next_states>
      </interaction_call>
    </event>
  </events>
</state>

<state id="connected">
  <events>
    <event id="disconnect">
      <interaction_call id="disconnect">
        <method id="arc.processing.business.handler.Disconnect"/>
        <next_states>
          <positive>
            <next_state id="disconnected"/>
          </positive>
        </next_states>
      </interaction_call>
    </event>
  </events>
</state>
```
Adaptation

Why
- To implement business interaction constraints for application classes
- To enable adapted interaction between applications

How
- Using XML representation
- Using data filtering
- Using dynamic adaptation

With
- A hierarchy of static application profiles (interaction and business)
- Dynamic adaptation rules
Interaction Processing

Why

- To control interaction
- To instantiate interaction upon business
- To implement communication between applications

How

- Depending closely upon adaptation and task management
- Coordinating input interpretation and output generation
- Relying upon real-time resource management

With

- A multi-application asynchronous interaction model
- An interaction context (interaction history & interaction state)
- A business context (business interaction patterns & application state)
Interaction Container

Vocal Natural Language Processing

Multimedia Generation

Multimodal Fusion

Dialogue Processing

Multimodality Engineering
Architecture for Multimodal Fusion

- GUI Input
- Vocal Natural Language Input
- Gesture Input
- Multimodal Fusion
- Dialogue Processing
- Multimodal Coordination
- Action Interpretation
- Reference Resolution

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Multimodal Fusion

Multimodal Coordination
- Function: management of modality calls & supervision of the fusion process
- Inputs: all events from all modalities
- Approach: rules identifying coordinated events according to time, information content, etc.

Multimodal Fusion
- Function: fusion of coordinated events from different modalities
- Inputs: coordinated events, to be merged
- Approach: rules for event fusion

Action Interpretation
- Function: computation of logical forms
- Inputs: user events pre-processed with recognisers (in normal form)
- Approach: rules to convert normal forms into logical forms

Reference Resolution
- Function: resolution of (multimodal) references i.e. conversion of logical forms into propositional forms (instantiated logical forms)
- Inputs: logical forms (including referring expressions)
- Approach: reference resolution algorithms based upon Mental Representation Theory
Architecture for Multimedia Generation

Multimodal Dialogue

Multimedia Generation

Information Fission

GUI Output

Vocal Natural Language Output

Animated Graphics Output

Media Selection

Spatial & Temporal Coordination

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Multimedia Generation

- Supervises the generation process
- Produces multimedia presentations
- Coordinates the other modules
- Sends requests for rendering to the different devices

Information Fission

- Divides global information into simple information items
- Preserves the relations between information items
- Uses fission rules
- Uses the semantic representation produced by the dialogue

Media Selection

- Selects the best media to use given the context
- Uses ergonomics rules, business rules, user preferences
- Uses external context (noise, light), user profile and device models
- Allocates the chosen media to information items

Spatial & Temporal Coordination

- Coordinates the whole presentation
- Creates referring multimedia expressions
- Arranges the presentation timing and coordinates medias and devices
- Uses a presentation planner
Approach for Multimodal Dialogue

Generalizing THALES Vocal System’s (TVS) approach for vocal natural language to multimodality
Multimodal Dialogue

Formalism

- Eventualities: states & events (including activities/processes)
- Application & user states (business entities & users as objects)
- Application & user events (business entities & users as participants)
- Temporal relations between states and events: eventuality graph

Model

- Dialogue & application state: state graph
- Dialogue history: eventuality graph
- Dialogue acts: communication events with propositional forms as participants
- Dialogue structure: tree of dialogue events & event groups

Function

- Pragmatic interpretation of user requests as propositional forms
- Dialogue with the applications (including other users)
- Expression of application events as propositional forms
- Generation of system answers as propositional forms
Application to Collaborative Decision Making in ATM

Data Sharing
Common Awareness
Inter-operability
Collaborative Processes

AIRPORT

RAMP MANAGEMENT
GROUND HANDLING
STAND & GATE

APP/TWR
ATFM/CFMU
ACC

ATS

AIRLINE

FLIGHT PLANNING
OPS CONTROL
STATION MANAGEMENT
COFOS/HIC: Focusing on User Adaptation

SECURE COMMUNICATION NETWORK

Application & Data Server

Groupware

Supervision & Administration

Post Flight Analysis Tools

Data Feed

Recording & Persistence

Source Management

Data Aggregation

Alert Generation

Contract Management

COFOS SERVER

Airline Dispatch

Punctuality Manager

Stand & Gate

Airport Resource Manager

Station Control

Ground Handler

Data Feed / Customization / Integration

COFOS CLIENTS
Architecture of the HIC Platform Implementation

Application Server (Java, C++/CORBA)

HIC Framework (Java, Perl, C++/iROS)

SOAP/HTTP (BlueTooth)

Mobile Phone HMI (Java Midlet)

SOAP/HTTP (WiFi)

PDA HMI (Java Swing)

Java RMI, JNI

Workstation HMI (Java Swing, C++)

JNI

Audio Framework (C++/OAA)

C++

Audio HMI (C++)

Database

PDA

Database + Server Tiers

Business Interaction Tier

Client Tier

Application Server

HIC Framework

SOAP/HTTP

PDA

Audio Framework

Audio HMI

Database

Java

Java Swing

Java Midlet