AS REAL-WORLD AS ANY SYSTEM COULD BE

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OVERVIEW

CHARACTERISTIC	APPLICATION 1	APPLICATION 2
[A] DESCRIPTION	Reactor operator companion - open loop control aid	Accelerator controller - closed loop control
[B] TIME	Soft real-time requirements - degradation acceptable	Hard real-time requirements - "deadman" embedded process
[C] NON-PRECOMPUTED CONTROLLER	Program size/complexity - too many possible states - simulation modelling OK	Program size/complexity - too many possible states - uncertain behavioural states preclude modelling
[D] RUN-TIME STRUCTURE	Reasoning - continuous simulation model available when intelligently applied to plant process Learning - possible neural net applicatn	Planning - STARTUP/MAINTAIN/SHUTDOWN /DIAGNOSTIC modes Reasoning - appropriate mode selection and troubleshooting
[E] REDUCING RUN-TIME LATENCY	Functional abstraction - society of processors & time-dimensional blackboard	Temporal abstraction - embedded controllers & high level knowledge-based master
[F & G] ARCHITECTURE-precompute -run-time	Numeric processes Symbolic processes	Embedded processor modes of op Heuristics that mimic expert
INTERCOMMUNICATION-[H] top down	General directives	Setpoints/goals/reference vals Tolerance of parameter values Modes of operation
-[I] bottom up	Data postings	Success of compliance Noted non-nominal parm values
[G] PERFORMANCE	Too premature yet	System fragile (non-robust)

NUCLEAR REACTOR OPERATOR COMPANION

CHARACTERISTICS:

- OPEN LOOP (HUMAN OPERATOR INVOLVED) SYSTEM

- COMPLEX PLANT PROCESS CONTROL AID IN TIMES OF HUMAN OPERATOR INFORMATION OVERLOAD

- SOCIETY OF HETEROGENEOUS PROCESSING ENGINES

- INTELLIGENTLY APPLIES A REAL-TIME SIMULATION MODEL FOR PLANT PROCESS TRACKING

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ACCELERATOR CONTROL SYSTEM

CHARACTERISTICS:

- CLOSED LOOP (HUMAN OPERATOR NOT DIRECTLY INVOLVED SYSTEM CONTROL) SYSTEM

- MULTIPLE SLAVE EMBEDDED REAL-TIME PROCESSORS

- EXPERT SYSTEM-BASED MASTER CONTROL

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TIME CONSIDERATIONS

REACTOR OPERATOR COMPANION:

- DATA (TIME SERIES DATA) CONCURRENCY MUST BE MAINTAINED

- TIMELY INTERCOMMUNICATION POSSIBLE VIA TIME-DIMENSIONAL BLACKBOARD (MESSAGE DATABASE)

- SLOW RESPONSE OF SYSTEM MEANS NON-CATASTROPHIC DEGRADED PERFORMANCE

ACCELERATOR CONTROL SYSTEM:

- REAL-TIME CONTROL SYSTEM, THEREFORE INFORMATION OVERRUN TO BE AVOIDED

- COMPUTER FAILURE AT INTELLIGENCE LEVEL WILL NOT LEAVE EMBEDDED PROCESSORS IN ACTIVE STATES (DEADMAN CONTROLLED)

CONTROLLER STRUCTURE -- PRECOMPUTABILITY

BOTH APPLICATIONS:

- PROCESS TOO COMPLEX FOR DECISION TREE ANALYSIS

- PROCESS TOO COMPLEX FOR LOOKUP TABLE / RESOURCE REQUIREMENTS / RESPONSE TIMES

REACTOR OPERATOR COMPANION:

- MODEL EXISTS BASED ON TRANSPORT EQUATIONS

- INTELLIGENT AGENT REQ'D TO APPLY SIMULATION TO TRACKING OF PLANT PROCESS IN REAL-TIME

ACCELERATOR CONTROL SYSTEM:

- UNCERTAIN PARAMETRIC VALUES (I.E. REPRODUCIBILITY) PRECLUDE MODELLING TECHNIQUES

- HEURISTICS REQUIRED TO MIMIC EXPERT OPERATOR

CONTROLLER STRUCTURE -- RUNTIME

REACTOR OPERATOR COMPANION:

- REASONING -- EXPERT COMPARISON OF MODELLED VS. REAL DATA RESPONSE OF SYSTEM

- LEARNING -- NEURAL NETWORK APPLICATION EMPLOYING PATTERN RECOGNITION

ACCELERATOR CONTROL SYSTEM:

- PLANNING -- APPROPRIATE INVOCATION OF **STARTUP/ MAINTAIN/SHUTDOWN/DIAGNOSE** OPER'G MODES

- REASONING -- DIAGNOSTIC TROUBLESHOOTING DUTIES OF EXPERT SYSTEM MASTER

RUN-TIME LATENCY REDUCTION

REACTOR OPERATOR COMPANION:

- **FUNCTIONAL ABSTRACTION** -- A SOCIETY OF HETEROGENEOUS (SYMBOLIC/NUMERIC) PROCESSORS

  -- ASYNCHRONOUS INTERCOMMUNICATION VIA A TIME-DIMENSIONAL BLACKBOARD

ACCELERATOR CONTROL SYSTEM:

- **TEMPORAL ABSTRACTION** -- EMBEDDED SLAVE PROCESSORS CHARGED WITH REAL-TIME OPERATION WITH THE HIGHEST DATA SAMPLING RATES

  -- SYMBOLIC PROCESSING MASTER CHARGED WITH ISSUING EXPERT CONTROL OVER PROCESS USING THE LOWEST TRANSFER RATE

CONTROLLER STRUCTURE -- DESIGN STRATEGY I

TOP-DOWN COMMUNICATION:

REACTOR OPERATOR COMPANION - SIMULATION DIRECTIVES TO MAINTAIN MODEL / PROCESS TRACKING (EG. TWO PHASE FLOW MODE)

ACCELERATOR CONTROL SYSTEM - COMMANDS AND DATA NECESSARY TO INVOKE OPERATIONAL MODES OF EMBEDDED PROCESSORS (EG. **MAINTAIN** MODE REQUIRES PARAMETER TOLERANCE WINDOW VALUES)

CONTROLLER STRUCTURE -- DESIGN STRATEGY II

BOTTOM-UP COMMUNICATION:

REACTOR OPERATOR COMPANION - DATA POSTING

(EG. SIMULATION RESULTS, DATA ACQUISITION SAMPLING RESULTS)

ACCELERATOR CONTROL SYSTEM - DETAILS OF

DEGREE OF COMPLIANCE

- NOTED NON-NOMINAL VALUES OF KEY PARAMETERS

CONCLUSIONS

PERFORMANCE:

- TOO PREMATURE FOR REACTOR COMPANION

- ACCELERATOR OPERATES WITH A SMALLER THAN EXPECTED DYNAMIC RANGE BUT WITH PERFORMANCE THAT EXCEED EXPERTS; THUS IS FRAGILE AND NOT YET ROBUST ENOUGH FOR EVEN EXPERIMENTAL DEPLOYMENT IN THE FIELD

FUTURE WORK:

- IMPLEMENTATION OF REACTOR SUBSYSTEMS INCLUDING BLACKBOARD AND TREND ANALYZERS

- INVESTIGATION OF THE ROLE THAT INTELLIGENT SELF-REFLECTION CAN PLAY IN GLOBAL COMPANION OPERATION

- EXTENSION OF KNOWLEDGE BASES TO REMOVE FAGILITY OF ACCELERATOR CONTROL SYSTEM

- BOTH SYSTEMS TO INCLUDE CRASH RECOVERY PROCEDURES