SOFTWARE PERFORMANCE EVALUATION OF A POLAR SATELLITE ANTENNA CONTROL EMBEDDED SYSTEM

G. Kasi Reddy1, SambasivaRao Baragada2, D. Sravan Kumar3 and B. Padmaja Rani4

1Research Scholar CSE JNTU Hyderabad, India
2Lecturer in Computer Science, Govt. Degree College, Khairatabad, Hyderabad
3Principal and Professor CSE KITE WCPE Shabad, R.R.District(Hyderabad), India
4Professor & Head, Dept. of CSE, JNTUH, Hyderabad, India

ABSTRACT

Performance evaluation of embedded system software unlike conventional software needs special attention and care. This must be achieved during the design phase of software. Antenna control systems generally, belong to soft real-time system well particular, polar satellite antenna control systems are used mainly in earth observatory systems. The thrust behind the performance evaluation of such systems is limited in the present available literature. This paper lists out various perform ance evaluation unexplored design methodologies for improved through put. Simulation results are also presented accordingly.

Keywords: Performance, polar satellite, antenna

1. INTRODUCTION

Over the last two decades, research has addressed the importance of integrating quantitative justification in the software development process, in order to meet nonfunctional requirements. Traditional software development methods focus on software correctness, introducing performance issues later in the development process. Software performance modeling techniques such as mathematical analysis [1, 2, 3, 4, 5], simulation [1] and performance oriented prototypes [6], performance solutions [7] can be used to predict and improve the performance of the software system being modeled. Embedded systems being the real-time systems, performance evaluation and improvement is still needs more exploration in such systems. Performance evaluation of household embedded systems like microwave oven, washing machines etc have less impact than compared to avionics, satellite systems, space shuttles etc. This paper focuses in software performance evaluation while designing the polar satellite antenna control embedded systems.

2. POLAR SATELLITE ANTENNA CONTROL SYSTEM

A Polar Satellite Antenna Control System (Refer figure 1) is normally leveraged in the setup of satellite real-time data transmission and/or communications. Normally, antenna system is driven by motors through a rotating belt. The rotating belt is equipped with a sensor (normally called home sensor, (Refer figure 2), that detects the co-ordinates of the antenna. Some key parameters are taken into consideration during the design and evaluation.

- Length/Diameter of the antenna
- Velocity of the antenna
- Current Azimuth angle
- Current Elevation Angle
- Current cross-level angle

3. PROCESS FOR A SINGLE SATELLITE PASS COVERAGE

Satellite coverage can be either ascending or descending according to its orbit design and life cycle. Figure 3 shows the transition model of an instance G, One rotating belt V and the associated control processes C with three drive motors fixed to the arms of the antenna. Processes V_end and C_end are associated to design a closed system. Both synchronization channels and shared variables are depicted in the figure 3. pc0, pc1, pc2, p0, p1, p2 are the synchronization channels and s0, s1, v0, v1 are shared variables.
Figure 1: X-Band Polar Satellite Antenna

Figure 2: X/L band Polar Satellite Antenna Home Sensor

Figure 3 The transitional model of the satellite tracking antenna system process per belt.
Universal variable definitions

The performance evaluation generally represented as Chi specification of the transitional model from Figure 3 is as follows:

```plaintext
model C1V1(val x1ini,x2ini: real) =
    | [ cont x1: real = x1ini, x2: real = x2ini
      , var v1: nat = 0, v2: nat = 0
      , s0: bool = false, s1: bool = false, s2: bool = false
      , chan pc0,pc1,pc2: void
      , p0,p1,p2: void
      :: G(pc0,p0)
          | | C1(v1,s1,pc0,pc1) || V1(x1,v1,s0,s1,p0,p1)
          | | C1(v2,s2,pc1,pc2) || V1(x2,v2,s1,s2,p1,p2)
          | | Cend(pc2)
          | | Vend(s2,p2)
    ]|
```

Channels p0, p1, p2 are used to synchronize the antenna position transition from the current to the next belt. Channels pc0, pc1, pc2 are directed synchronization channels. Variables s0, s1, v0, v1 are shared variables, where s0 and s1 represent the sensors that indicate the presence of a home sensor, and v0 and v1 are actuators that determine the velocity of the respective motors. The process definitions are:

```plaintext
proc G(chan pc!: void, p!: void) =
    | [* (pc!; delay 1.0; p!!) ]|

proc Cend(chan pc?: void) =
    | [* pc? ]|

proc V1( cont x: real, var v: nat, var sprev: bool, s: bool, chan pin?,pout!: void) =
    | eqn dot x = ( x < -0.5 -> 0.0 | x >= -0.5 -> v*1.0 )
    | | | [ mode waitforTray = ( pin?
          ; x := 0.0
          ; x >= 3 -> sprev := false; waitforSensor
    )
    , waitforSensor = ( x >= 5 -> s := true
          ; x >= 6 and v > 0 -> pout!
          ; x := -1.0; waitforTray
    )
    ]:: ( x = -1 -> skip; waitforTray
    | x >= 0 and x < 3 -> !! "Error, incorrect initial value for x"
          ; deadlock
    | x >= 3 -> skip; waitforSensor
    )
```

Volume 2, Issue 1, January 2013
Control and timing preservative paradigm

The work can commenced with a conservative control strategy, where a triplet of azimuth, elevation and cross-level angles is allowed through home sensor thus indicating the electromechanical signals initiated to the rotating belt, after the previous spatial coordinates has reached the sensor completely.

\[
\text{proc C1(var } v: \text{ nat, var } s: \text{ bool, chan } \text{ pcin?,pcout!: void) =}
\]
\[
|\text{[ mode emptyon = ( ( pcin?}
\]
\[
\text{ delay 5.0; } v := 0; \text{ pcin?; } v := 1}
\]
\[
\text{ ) ; entering}
\]
\[
\text{) , mode entering = ( s -> skip; atsensor)}
\]
\[
\text{ , mode atsensor = ( pcout!; leaving}
\]
\[
\text{ delay 0.2; } v := 0; \text{ pcout!; } v := 1; \text{ leaving}
\]
\[
\text{ ) , mode leaving = ( not s -> skip; emptyon}
\]
\[
\text{ )} \]
\[
\text{) :: } v := 1
\]
\[
\text{ ; ( s -> skip; atsensor}
\]
\[
\text{ delay 3.0; empty on}
\]
\[
\text{ ) ]}
\]

Figure 4 show simulation result for antenna system that is initially rest and system where the initial positions of the antenna are 180° and 300° azimuth angles with respect to 90° elevation angle.

Figure 3 Antenna System initially at selected idle state

Improved throughput paradigm
The throughput of the system can be improved by accurate positioning of antenna for maximum possible values of azimuth and elevation values. To achieve this goal, a new mode is added to the controller, providing the next position value as soon as the expected position is reached. This can be represented as:

```verbatim
proc C2(var v: nat, var s: bool, chan pcin?, pcout!: void) =
[mode emptyon = ( (pcin?
| delay 5.0; v := 0; pcin?; v := 1)
); entering
)
, mode entering = ( s -> skip; atsensor)
, mode atsensor = (pcout!; leaving
| delay 0.2; v := 0; pcout!; v := 1; leaving)
, mode leaving = ( not s -> skip; emptyon
| pcin?; leaving_entering
)
, mode leaving_entering = ( not s -> skip; entering)
:: v := 1
; ( s -> skip; atsensor
| delay 3.0; emptyon)
]|
The other processes remain the same, leading to model C2V1.

model C2V1(val x1ini, x2ini: real) =
[cont x1: real = x1ini, x2: real = x2ini
, var v1: nat = 0, v2: nat = 0
, s0: bool = false, s1: bool = false, s2: bool = false
, chan pc0, pc1, pc2: void
, p0, p1, p2: void
:: G(pc0, p0)
|| C2(v1, s1, pc0, pc1) || V1(x1, v1, s0, s1, p0, p1)
|| C2(v2, s2, pc1, pc2) || V1(x2, v2, s1, s2, p1, p2)
|| Cend(pc2) || Vend(s2, p2)
]|
```

However, the system sometimes shows undesired behavior. Huge amount of data gaps can be found. This can be resulting of many reasons: Lack of recent orbital elements, GPS time sensor might not be synchronized, control system is busy with other priority tasks, and the poor synchronization of the drive motor to the given embedded signals. In the mode waitforSensor, the synchronization pout! is set delayed, allowing the antenna to move desired position.

- **Enhanced drive belt model (One feasible early solution)**

To eliminate the poor response the first and best solution is the improved drive belt design. The tooth of the belt is restructured to increase or decrease the tooth. This can be represented as:

```verbatim
proc G2(chan pc!: void, p!: real) =
/* (pc!; delay 1.0; p!!0.0 ) */

proc V2( cont x: real, var v: nat, var sprev: bool, s: bool, chan pin?, pout!: real) =
/* eqn dot x = ( x <- 0.5 -> 0.0 | x >= -0.5 -> v*1.0 ) */
|| /* mode waitforTray = ( pin?x
; x >= 3 -> sprev := false; waitforSensor
) */
, waitforSensor = ( x >= 5 -> s := true
; x >= 6 and v > 0 -> pout! x - 6
; x := -1.0; waitforTray
```
:: (x = -1 -> skip; waitforTray
  | x >= 0 and x < 3 -> !! "Error, incorrect initial value for x"
    | deadlock
  | x >= 3 -> skip; waitforSensor
) /

model C2V2(val x1ini,x2ini: real) =
  [ cont x1: real = x1ini, x2: real = x2ini
    , var v1: nat = 0, v2: nat = 0
    , s0: bool = false, s1: bool = false, s2: bool = false
    , chan pc0,pc1,pc2: void
    , p0,p1,p2: real
  :: G2(pc0,p0)
    || C2(v1,s1,pc0,pc1) || V2(x1,v1,s0,s1,p0,p1)
    || C2(v2,s2,pc1,pc2) || V2(x2,v2,s1,s2,p1,p2)
    || Cend(pc2) || Vend2(s2,p2)

The solution is can be simulated to various possible initial boundary conditions combined with other proposed solutions. As the structure of the drive belt is enhanced or modified, the model works positively with the accurate values of orbital positions.

- **Local spatial position variable declarations (Second feasible solution)**

Traversing various solutions can yield the optimal solution model. Modeling the system using local variables for the positions of the antenna might give a fruitful behavior, thus leading to the following model:

model Cvlocal() =
  [ var v1: nat = 0, v2: nat = 0
    , s0: bool = false, s1: bool = false, s2: bool = false
    , chan pc0,pc1,pc2: void
    , p0,p1,p2: void
  :: G(pc0,p0)
    || C1(v1,s1,pc0,pc1) || Vlocal(v1,s0,s1,p0,p1)
    || C1(v2,s2,pc1,pc2) || Vlocal(v2,s1,s2,p1,p2)
    || Cend(pc2) || Vlocalend(s2,p2)
] /

Here changes include the velocity of each conscan drive motor associated to each arm of the antenna and can be represented as:

proc Vlocal(var v: nat, var sprev: bool, s: bool, chan pin?,pout!: void) =
  [!*pin?
    | ![ cont x: real = 0.0
      :: ( eqn dot x = v*1.0 | x >= 3 -> sprev := false )
      ; ( eqn dot x = v*1.0 | x >= 5 -> s := true )
      ; ( eqn dot x = v*1.0 | x >= 6 -> pout!! )
    ]
  ]

proc Vlocalend(var sprev: bool, chan pin?: void) =
  [!* ( pin?
    | ![ cont x: real = 0.0
      :: ( eqn dot x = v*1.0 | x >= 3 -> sprev := false )
      ; ( eqn dot x = v*1.0 | x >= 5 -> s := true )
      ; ( eqn dot x = v*1.0 | x >= 6 -> pout!! )
    ]
  ]
The algebraic notation of the variables of the sensors can be represented as:

```plaintext
model CBalg(val xini,yini,zini: real) = 
  [ cont x: real = xini, y: real = yini, z: real = zini 
    , var v1: nat = 0, v2: nat = 0 
    , alg s1,s2: bool 
    , chan pc0,pc1,pc2: void 
    , p0,p1,p2: real 
    :: eqn s1 = ((x >= 0 and x <=360) or (y >= 0 and y <= 90) or (z >=5 and z <= 85)) 
    , Galg(pc0,p0,p1,p2) 
    , C(v1,s1,pc0,pc1) 
    , C(v2,s2,pc1,pc2) 
    , Cend(pc2) 
    , PosAlg(x,v1,v2,p0) 
    , PosAlg(y,v1,v2,p1) 
    , PosAlg(z,v1,v2,p2) ]

proc Galg(chan pc!: void, p0,p1,p2!: real) = 
  [
    *( pc!; delay 1.0 
      ; (p0!!0.0 | p1!!0.0 | p2!!0.0) 
    ) ]

proc PosAlg(cont x: real, var v1,v2: nat, chan pin?: real) = 
  [
    mode empty = 
      ( (eqn dot x = 0 | pin?x); tray ) 
    , mode tray = 
    )

:: ( x = -1 -> skip; empty // assume initially x = -1 or x >=0 
    | x >=0 -> skip; tray 
  )
```

4. CONCLUSION

The paper has presented some unexplored design paradigms of software evaluation while designing the embedded systems well particular like polar satellite antenna control systems. Adequate simulations can be done using the models specified in this paper. These models can further be enhanced with other feasible solutions which has direct impact in target embedded system.

REFERENCES


VIII SCCC International Conference on Computer Science, Santiago, Chile July 1988, 25-43


AUTHORS

G. Kasi Reddy (Member ISTE) received his B.E (CSE) from Marathawada University, Aurangabad, in 1992 and M.Tech (S.E) from JNTU Hyderabad in 2001. He is pursuing his Ph.D at JNTUH Hyderabad. At present he is a Associate Professor in the Department of Information Technology at Mahatma Gandhi Institute of Technology (MGIT), Hyderabad -500075. His research interests include Software Engineering, Software Performance Engineering and Embedded Systems.

Dr. Sambasiva Rao Baragada received his M.Sc and M.Phil in Computer Science in 2001 and 2006 respectively. He is awarded his Ph.D in Computer Science from Sri Venkateswara University, Tirupati in the year 2011. Formerly he was associated as Scientist at Satellite Data Acquisition & Processing System (SDAPS), Data and Information Management Group (DMG), Indian National Center for Ocean Information Services (INCOIS), Ministry of Earth Sciences, Govt. of India, Hyderabad. With a high passion in teaching and research, at present he is working as Lecturer in Computer Science in Govt. Degree College, Khairatabad, Hyderabad. He has published numerous articles in International Journals and Conferences.

Dr. D. Sravan Kumar is working as Principal and Professor of CSE at KITE womens college of Professional Engineering Sciences, Shabad, R.R. District (Hyderabad). He had done his M.Tech (CSE), PhD. To his credit he had publications in various International Journals and International Conferences. He is the editorial board member in various International Journals. His research interests include Web Mining, Security Architectures, Agile Modeling, Software Engineering, Embedded Systems.

Dr. B. Padmaja Rani is working as Head, Dept. of CSE at JNTUH college of Engineering Hyderabad. She had done her M.Tech(CS), Ph.D. To her credit she had publications in various International Journals and International Conferences. Her research interests includes Natural Language Processing, Information Retrieval, Embedded Systems, Security Architecture.