Design of a Treatment Control System for a Proton Therapy System

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TUOAFI02
Figure 1. The MPRI facility showing the IUCF Cyclotrons, Trunk and ES lines, Treatment Rooms and Clinic.

WEPCH179  D. Friesel, et al., The Indiana University Proton Therapy System
Partition System Functions

• Beam line control
  - Mimic cyclotron controls

• Dose measurement
  - Realtime measurements and response

• Patient positioning
  - X-Ray adjustment

• User interface
  - Medical data access, interpretation, distribution
Main Patient Therapy Flow Chart

Patient arrive at MPRI

- Diagnosis / Make mask / Markup for scanning

- Scan Patient: MRI / CT

  - Transfer CT data to TPS system

- Treatment planning / Process - Outlining / Image fusion / Planning

- Plan Approved Physicist + Med Phys

- Transfer Data to Central Data Base Server

- Prepare treatment chart

- Prepare compensators / apertures / modulators

- QA / Dosimetry

- Treatment Simulation (with patient)

- Positioning Simulation/QA

- Positioning Dry Run (without patient)

- Update data in Central Database Server

Ready for treatment

Medical Physics to review Plan

Call Patient: Treat Cycle

- Possible / ready to treat

- Treatment Simulation (without patient)

- To another page

Legend:

User Interface Location

- External RTT Station
- Both Ext and Int
- Internal RTT Station
- Internal RTT and pan/don enable

To another page

From another page
Each button's Ack includes disabling that button.
• Decide on distributed system
  – Allows use of different operating systems, platforms.
  – Allows separate development rates.
  – Requires well defined set of interfaces.
Major Systems (Software)

BDS – Set and monitor all beam line devices
  Vsystem, C, OpenVMS

DDS – Monitor dose delivery
  C, QNX

PPS – Set patient position
  Robot DLL, C#(.Net), Windows

TRCS – Coordinate treatment process
  C++, (Why not) Linux (?)

Minor Systems (No Software)

MIRS - Radiation Safety

KES – Kicker Enable

ESS – Emergency Stop
Network Communication

- TCP/IP + Ethernet
- XML-based message protocol
  - System independent
  - Schema checking
  - Existing software packages
- Receiver required to check ranges of all input parameters.
Messaging Details

• No message echo.
• Messages are entirely ASCII text.
• Expect immediate reply within a timeout (empirically determined).
• Define (delayed) replies to commands that initiate “long” processes.
• Allow asynchronous (error) messages.
Testing

- Code review
- Unit testing
- Integration testing
- Formal Software Test
- Formal System Test

In all cases

- Happy path, Sad path
- Isolation = emulation, NePTUNE
- Time is ALWAYS underestimated
Testing

Treatment
System Design
Specification

<Specific>
System Design
Specification

<Specific>
System Test
Procedure

<Specific>
System Software
Requirements

<Specific>
System Software
Specification

<Specific>
System Design
Specification
TR2 BDS SETUP

TREATMENT PARAMETERS
- RANGE: 27.00 cm
- ENERGY SPREAD: 2.50 cm
- INTENSITY: 2.00 nA

TREATMENT PARAMETERS
- GANTRY ANGLE: 270.0 Deg

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REQUESTED SLIT POSITION: 0.750

BDS MESSAGES:
ES2 ENERGY SETUP COMPLETE...
MUST BE AT STANDBY TO TOGGLE LOCAL/REMOTE!

BDS SETUP
- DEGRADER: -24.4 mm
- ES2 BM 1 & 2: 878.0 A
- TR2 BM 2: 308.1 A
- VACUUM GATE VALVES
- POWER SUPPLY STATUS
- LIMIT3 MONITOR: OK

KES STATUS
- WATCHDOG
- ENABLE
- TRCS
- BDS
- BHS
- MRS
- DDS
- DT1
- WOBBLER
- STOP
- ICBM
- JUSTIS

COMMANDS
- Treat Done
- Stop
- Start
- Do Prime
- Do Setup
- Enter Values
- Treat. Reset

BDS STATE
- DEAM ON
- BEAM READY
- PRIMING
- ES2 SET UP
- SETUP STARTED
- VALUES RECVD
- STANDBY
- RESET STARTED
- ES2 OFF

REQUESTED SLIT POSITION: 0.750
0.000 SLIT POS

MLFC POS
- OUT
- 32 - 360.0
- 27 - 32
- 22.3 - 27
- 17.5 - 22.3
- 12.6 - 17.5
- 7.0 - 12.6
- 3.0 - 7.8

ICBM
- VERTICAL
- HORIZONTAL

DATA
- D 0.00 V
- L 0.00 R
- 0.06 ICBM

Loop 1 OFF
Loop 2 OFF
Loop 3 OFF
Spot size check ON