MAYO CLINIC

Physicists Role in Digital Imaging Informatics Systems

AAPM 2006

Disclaimers

- Speaker is on the Medical Advisory Board of Teramedica and Siemens Medical
- Any opinions expressed are those of the speaker alone (and maybe not even him)

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Talk Overview & Learning Objectives

- Classical Role of Medical Physicist
- Role with DICOM Modalities
- Role in Design of Image Storage, Display, Management, Workflow reengineering, Uptime
- Case Studies of Value Add of Physicists

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Classical Role

- Compliance
  - FDA (MQSA, state)
  - ACR Accreditation
  - Radiation safety, patient dosimetry, shielding
- Education
  - Residents, Techs, Patients
- Optimization
  - Best image quality for the dose
  - Comparative knowledge of imaging offerings from many vendors

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Classic Role

- Technology Expert
  - Expected to be abreast of the newest imaging technologies
- Experimental Skills
  - understand the relationships of acquisition variables on imaging equipment
  - Able to conceive and execute experiments to optimize imaging parameters

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Physics Role In Digital Modality Issues

- Everything the classical physicist does *plus*
  - the analogous features in the DICOM modality world
  - an understanding of Dose vs. Noise instead of Dose vs. Over/Under exposure
  - Reeducation of Techs, Radiologists and others of implications of digital imaging

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Role In Digital Modality Issues

- Why the physicist?
- Unique Skill Set Combination
  - We are Data driven
  - Knowledge of radiographic anatomy and examination technique
  - Expert knowledge of imaging parameters, technology, experimental method
  - Expert at QA and process optimization
  - Educator of imaging technologists

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Sometimes reticent ...

- I'm already overworked
- I'm board certified and already trained in all this stuff with ongoing CME's
- There are few regulations that require physics oversight of Digital Imaging
- What's in it for me?

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Esprit de Corps

- What do these people have in common?
  - Wilhelm Roentgen
  - Allan Cormack, Godfrey Hounsfield
  - Ray Damadian
- Answers
  - physicist, inventor of X-ray
  - physicists, inventor of CT
  - MD, but undergrad applied math, inventor MRI

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Competitive Advantage

- Benefit to Care Providers going Digital
  - leverage their radiology staff to cover remote in-network sites
  - read for clients seen at non-network sites
  - Any image, anywhere (ideally in EMR)
- Benefit for the Physicist
  - the physicist that can take clients to the “filmless” promised land will be in demand

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And One Last Reason

- There are talkers and doers
  - Try to be in the second group
  - Why?
- Less Competition
  - M. Ghandi

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Digital (DICOM) Modalities

- Concerns?
  - Dose for Dx image quality (DQE)
  - DICOM functionality (Worklists, Store, Print, PPS, GSPS)
  - Workflow reengineering
  - Exam Fidelity from Modality through Archive and Clinical Viewer

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ESE for Dx Images

- Plain Film (400 speed screens)
  - PA chest 12-18 mR
- CR
  - Up to 50% more for same noise
- DR
  - Similar or maybe 20% less then film for same noise (Huda)

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DICOM Modality Functionality

- Minimum DICOM requirements for PACS
  - Store, Print, Store Commit, Modality Worklist
- Better for IHE Levels of Integration
  - PGP (e.g. head, neck, chest CT)
  - PPS (permit scanner side QA to update exam status on RIS)
  - GSPS (assure QA work on Scanner is presented to PACS and other downstream systems)

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Workflow Reengineering

- Exam Acquisition Workflow
  - Pre-PACS sequence from Order to presentation of films to Radiologist is often “anything goes”
  - Post-PACS requires strict sequence:
    - Order (Pat, Anatomy, Exam code) from HIS to RIS sends orders to PACS
    - Night before PACS kicks off compares prefetch for known orders
    - On Arrival, order goes to Modality Wklist broker
    - Scanner gets exam info. from Broker
    - Exam is QA’ed in PACS and completed in RIS
    - Now, Radiologist sees images

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Exam Fidelity from Source to Archive

- How to assure?
  - Random manual check of exam content (demographics, series and image counts, aided via DICOM Store Commit)
  - Manual examination of Image appearance and caliper accuracy on known objects on downstream viewers
  - Preservation of all QA operations across all viewers (aided via DICOM GSPS)

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Role in Radiology *Systems* Design

- Why the Physicist?
- … well, who else?
  - IT?
  - RT?
  - Radiologist?
  - Bioengineering?

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Role in Radiology *Systems* Design

- Perry Sprawls says:
  - R&D of Technology
  - Equipment Acquisition
  - Facility Planning
  - Evaluation of Equipment Performance and QA
  - Reduce Physical Risk Associated with Medical Imaging Procedures
  - Optimize Imaging Procedures Through Education and Training

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W/ permission, Willis

Physicist Training

- Formal training in the imaging chain
  - *acquisition, display, storage, and distribution*
- Broad experience in radiology operations
  - *needs of technologists, radiologists / referring physicians*
- Experience with medical devices
  - *hardware and software*
  - *specification, installation, and acceptance*
  - *service activities*
- Familiar with sources of technical information
- Inherent interdisciplinary training

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Physicist Communication

- Ability to tailor communications
  - *Vocabulary (jargon) is specialized and parochial*
    - IS *vs*. RT *vs*. Clinical Engineer *vs*. Physician *vs*. Administrator
  - *Must summarize details and report*
    - both oral and written communications critical

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Physicist Status

- As a member of the Medical Staff of the Hospital, the Medical Physicist ...
  - *represents the interests of the Medical Staff.*
  - *interacts with the Medical Staff as a peer.*
  - *is included in closed meetings that involve discussion of QA incidents, such as Morbidity and Mortality.*
  - *carries greater authority with hospital staff.*
  - *is expected to design and direct the QA program, rather than to conduct it personally.*

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Storage Issues

- Brand New 64 slice CT scanner
  - will the Radiologist/CT-Vendor be thinking about explosion of data about to hit the PACS archive?
  - Will the networking team at the hospital be ready with Gbit links to the scanner and PACS workstation?
  - Will IT or PACS vendor be thinking about the RAM needs of PACS workstations?

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Display Issues

- Is the image fidelity maintained from:
  - modality console to
  - PACS displays to
  - Clinical viewer?
- Are measurements accurate from modality to PACS to Clinical Viewer?
- Does the Display offer the proper JNDs required for the task (Dx, Clinical)?

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Management and Archive Issues?

- Are imaging exams routed to required targets (EMR, research, Rad-Onc) in a timely manner?
- Is archive depth sufficient for needs given exam growth and modality changes?
- Are images used for non-clinical purposes properly de-identified?
- Are mission critical systems fault tolerant?
- Are vendors compliant with industry standards (DICOM, IHE)?

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Workflow Reengineering

- How is QA performed to assure consistent image appearance everywhere?
- Are checks in place to assure all orders are ultimately processed, QA'ed and Reported with accurate demographics?
- How is post-exam 3D processing coordinated with normal exam workflow?

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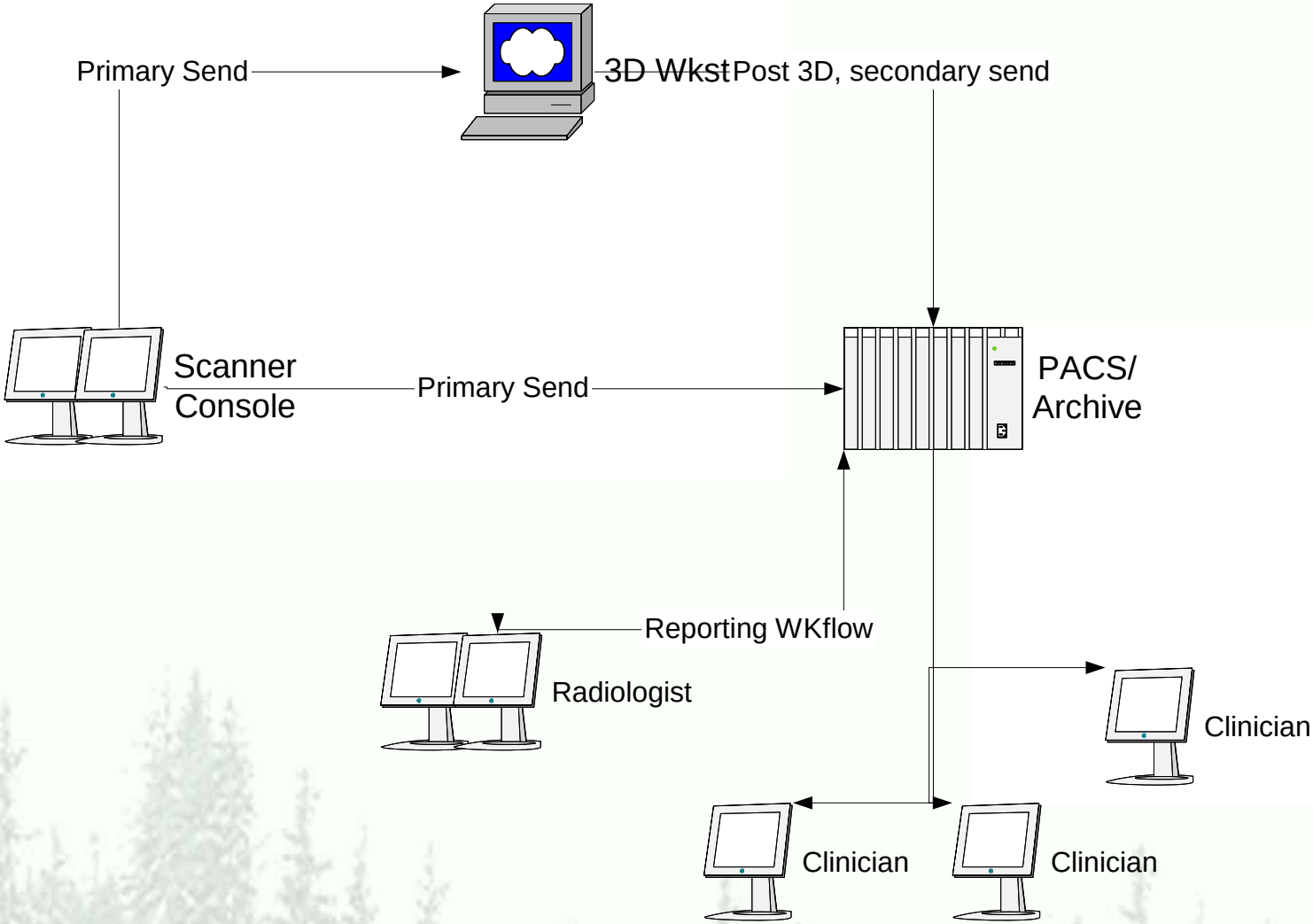
Post-Processing Workflow



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Uptime Issues

- Perfect World
  - Physicists solves Workflow and Image Quality then pursues other interests
- Reality
  - Systems break
  - Downtime procedures in a filmless world are more complex and require highly adaptable/targeted downtime plans
  - Physicist to the rescue!

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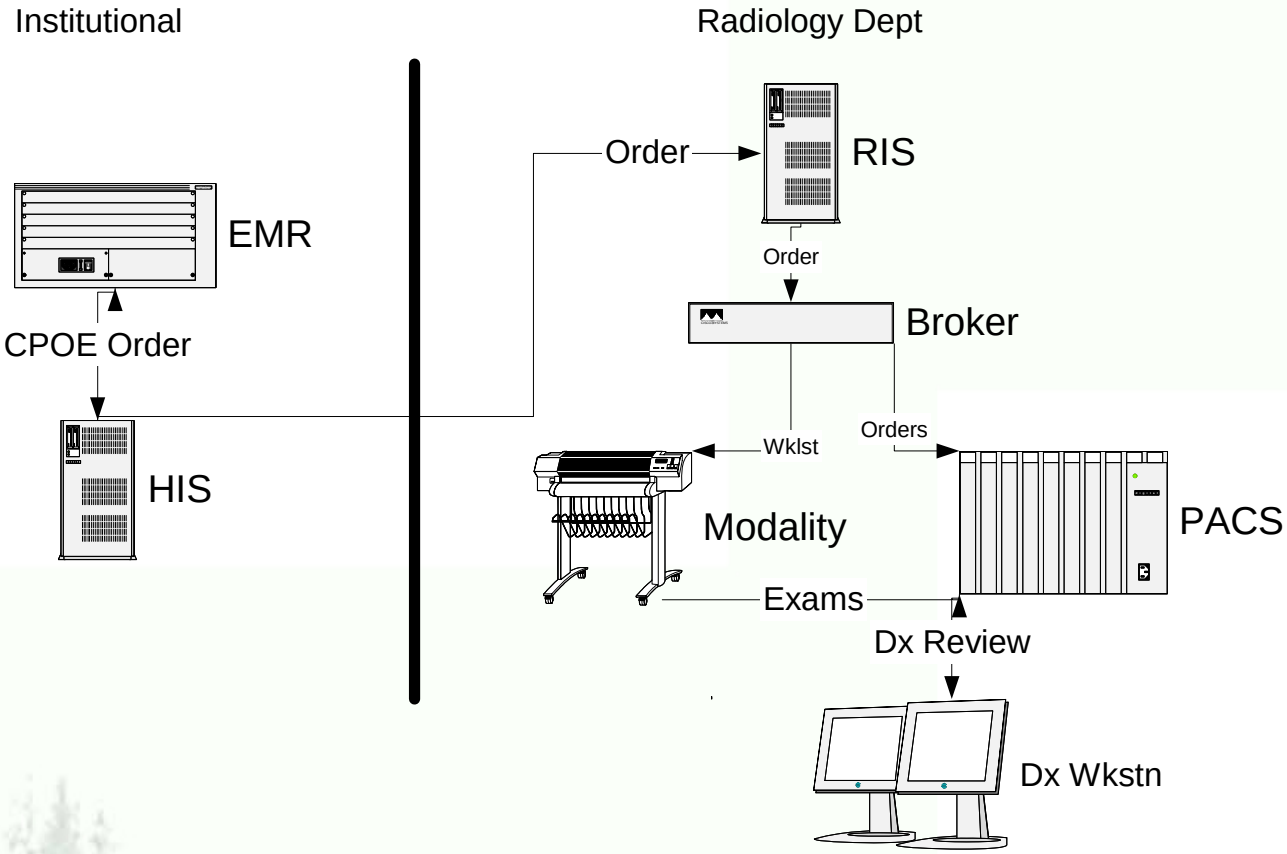
Uptime Issues



PACS Lottery (99% System Up = 3.6 days/year of outage/degraded performance)

.99^7 = 93.2% System uptime .995^7 = 96.5% System up .999^7 = 99.3%

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Break-fix & Dashboard

- Downtime Plans
  - have to respond to what is down
  - but, they may not be obvious
- Need a System Dashboard
  - Collects all logs/conditions from critical components in one place for Display and Monitoring
- Downtime plans
  - respond to what is broken

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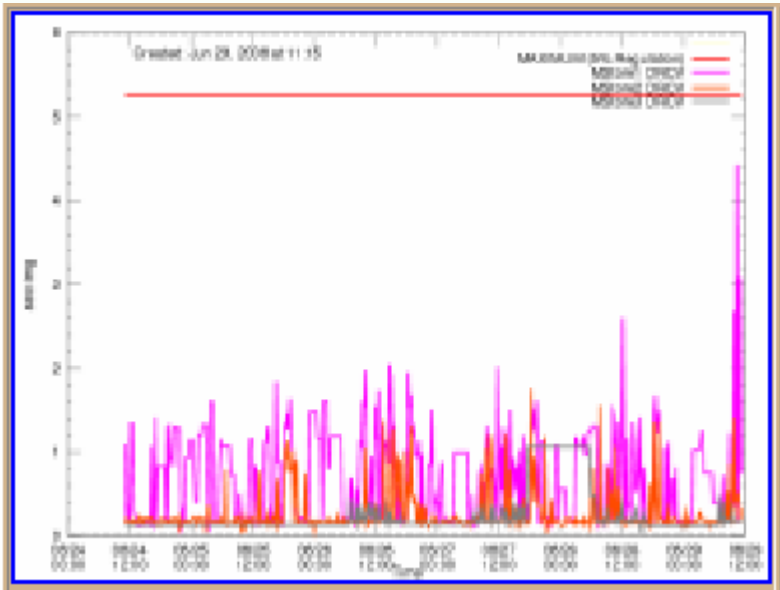
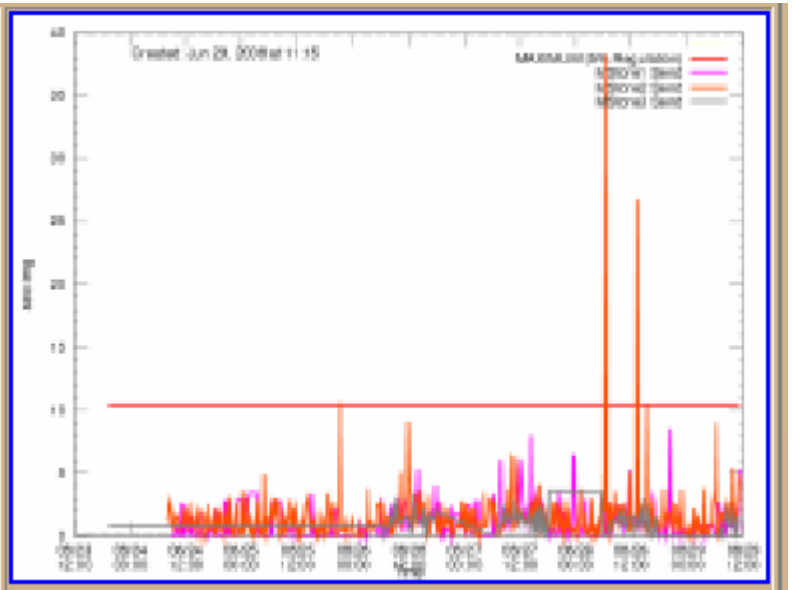
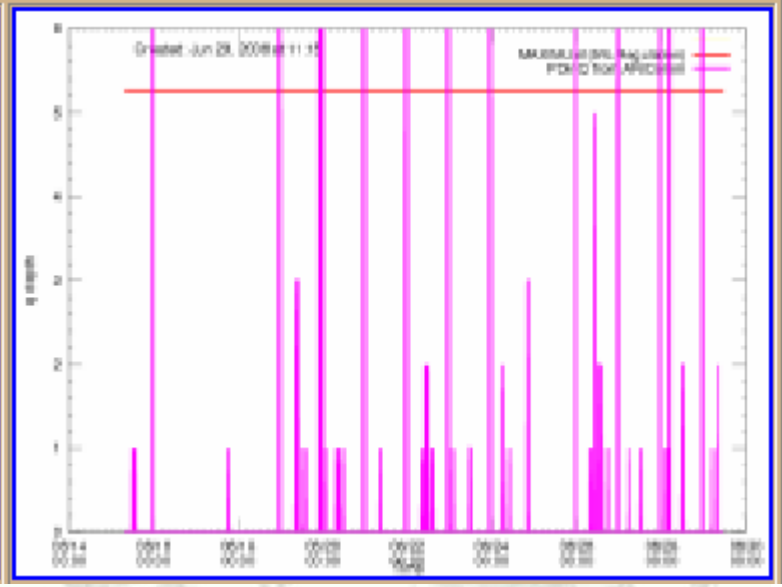
Dashboard



DICOM Rcv Performance



DICOM Sender Performance



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Case Study 1: Archive

- Challenge: the vendor's workflow design had modalities going into Archive *first*
  - Then the PACS would retrieve the exams
  - The exam would be QA'ed and Reported
  - Finalized exam would go back to the archive

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Case Study 1: Archive

- Why would the vendor design such a serpentine path?
  - Because, their licensing model was based on number of DICOM inputs
- Resolution
  - Physicist redesigned data flow through PACS with one input to Archive
  - Saved $4M
  - Vendor rethought licensing model

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Case Study 2: Clinical Viewer

- Challenge: Clinicians require Clinical Viewers have same 3 Mpixel Dx Gray-Scale displays as PACS workstations
- Response: Designed ROC experiment
  - compared Sensitivity/Specificity of Clinicians across 4 displays under exam room conditions
  - Differences statistically insignificant for 3 displays, but the Sens. scores were higher on non-3 Mpixel display in contrast to self-reported assessment

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Case Study 2: Clinical Viewer

- Resolution
  - Institution decided on business class displays
  - Savings: > $10K per seat (500 seats and counting)

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Summary

- Suggested roles for physicist
  - leadership role in selection of modalities
  - leadership role in architecting data and workflow
  - lead designer of QA program, exam fidelity across all display systems
  - Large participant in design of Imaging Informatics Systems for performance, fault tolerance and other user/IT concerns
  - Chief negotiator/tormentor of vendors

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