z/VM Live Guest Migration

MVMUA
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IBM System z Software – Strategy and Design

IBM Systems

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Agenda

- Motivation
- Alternatives
- Early Steps
- Technology
- Conceptual Migration Process
- Technology Demonstration
- Challenges
- Summary

Motivation

- z/VM is extremely reliable
  - Customers “complain” about having to IPL to/from Daylight Time
  - Still, z/VM is a single point of failure
  - More importantly, perhaps, it is a single point of service
    - Planned hardware and software outages predominate
- VMware, Xen, pHyp, and other hypervisors have found value in guest migration
  - Addressing a somewhat different set of problems than z/VM has
    - Reliability
    - Scalability limitations
  - A differentiating factor nevertheless
  - Caused us to reconsider its importance

Alternatives

- Concurrent patch
  - Firmware approach
  - Must be able to apply and remove patches
  - Number of combinations grows exponentially
    - Difficult to test
  - Could cause more problems than it solves
- Application migration
  - E.g., MetaCluster
  - Probably leaves virtual machine impotent
  - Knowledge at the wrong level
- Multi-system virtualization
  - “Single system image” including Live Guest Migration
  - Breadth of z/VM virtualization leads to large, complex challenge

Early Steps

- IBM Research interest in problem of z/VM Live Guest Migration
- Started prototype work in 2004
- Speed Team created in summer 2006
  - Cross-site (Poughkeepsie, Endicott) team with Research assistance
  - Brought prototype forward to z/VM 5.3 base – Endicott
  - Designed Migration Diagnose – Endicott/Poughkeepsie
  - Developed Migration Diagnose – Endicott
  - Developed service machine ("moving van") to orchestrate migration – Poughkeepsie
    - Based on CSE and ISFC

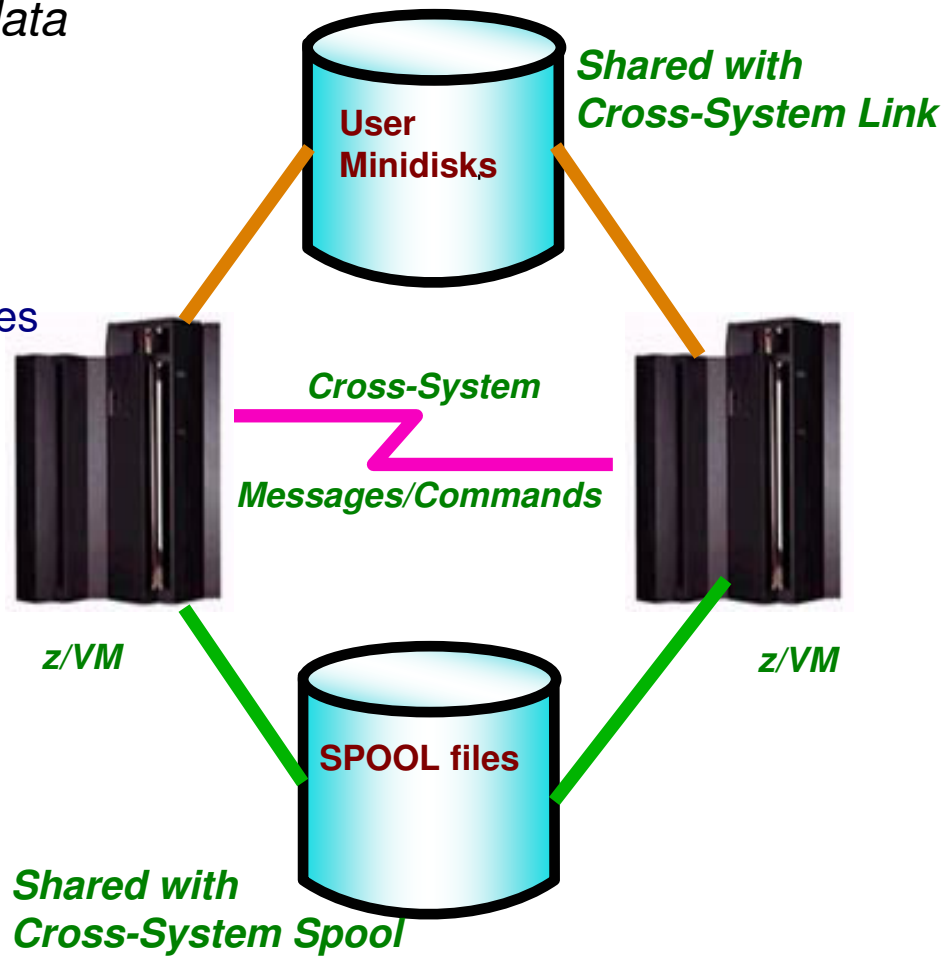
Technology

- **Cross-System Extensions (CSE)**
- **Inter-Systems Facility for Communications (ISFC)**
- **“TRACK” Diagnose**
- **Migration Diagnose**
- **Guest memory change tracking**

Cross-System Extensions (CSE)

Virtual Machines may access their data from any z/VM image in a cluster

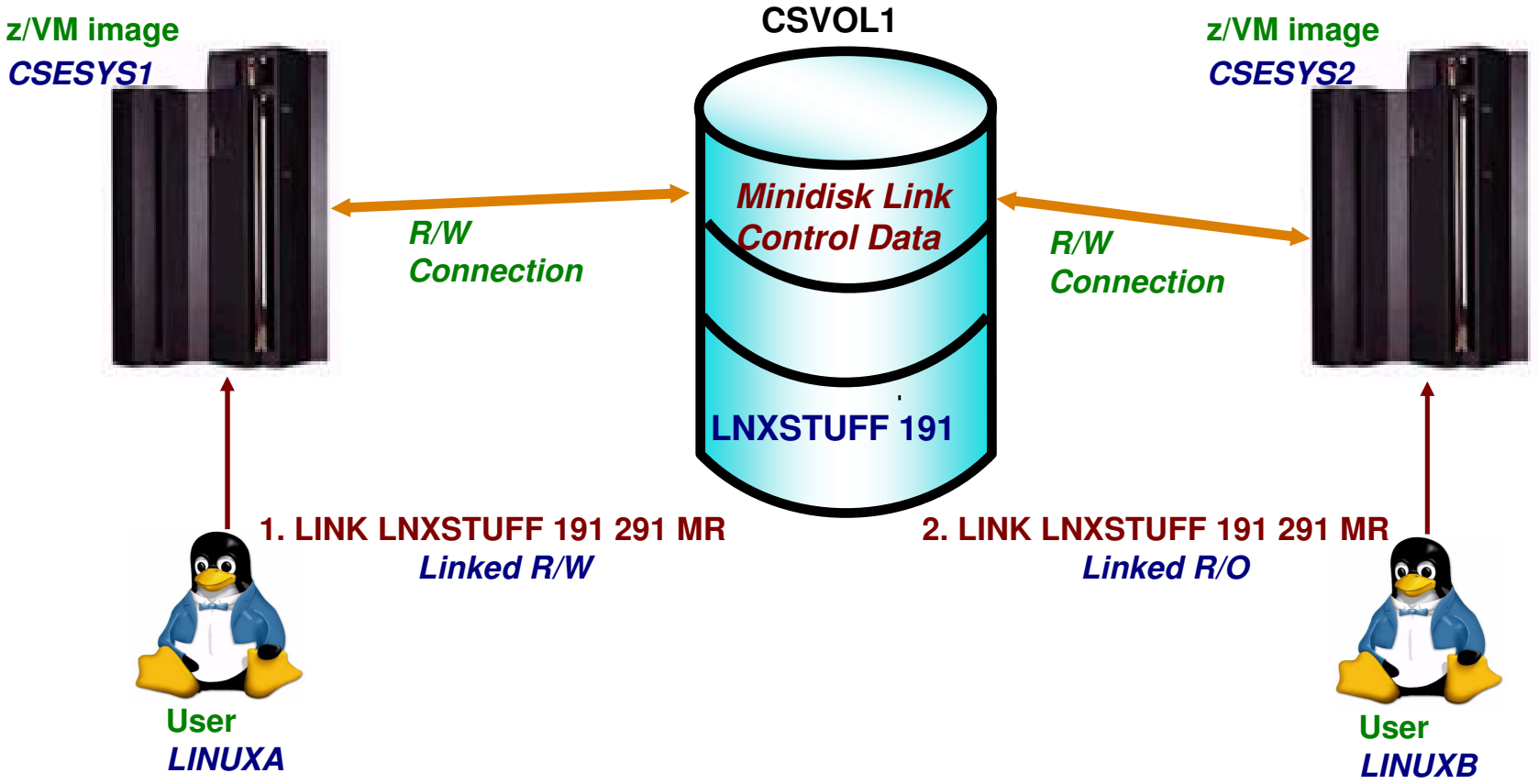
- Capability to share
  - Minidisks
  - Spool files
- Commands may be sent among images in the cluster
  - Messages
  - Query
  - Link
  - Spool File Commands



CSE Cross-System LINK

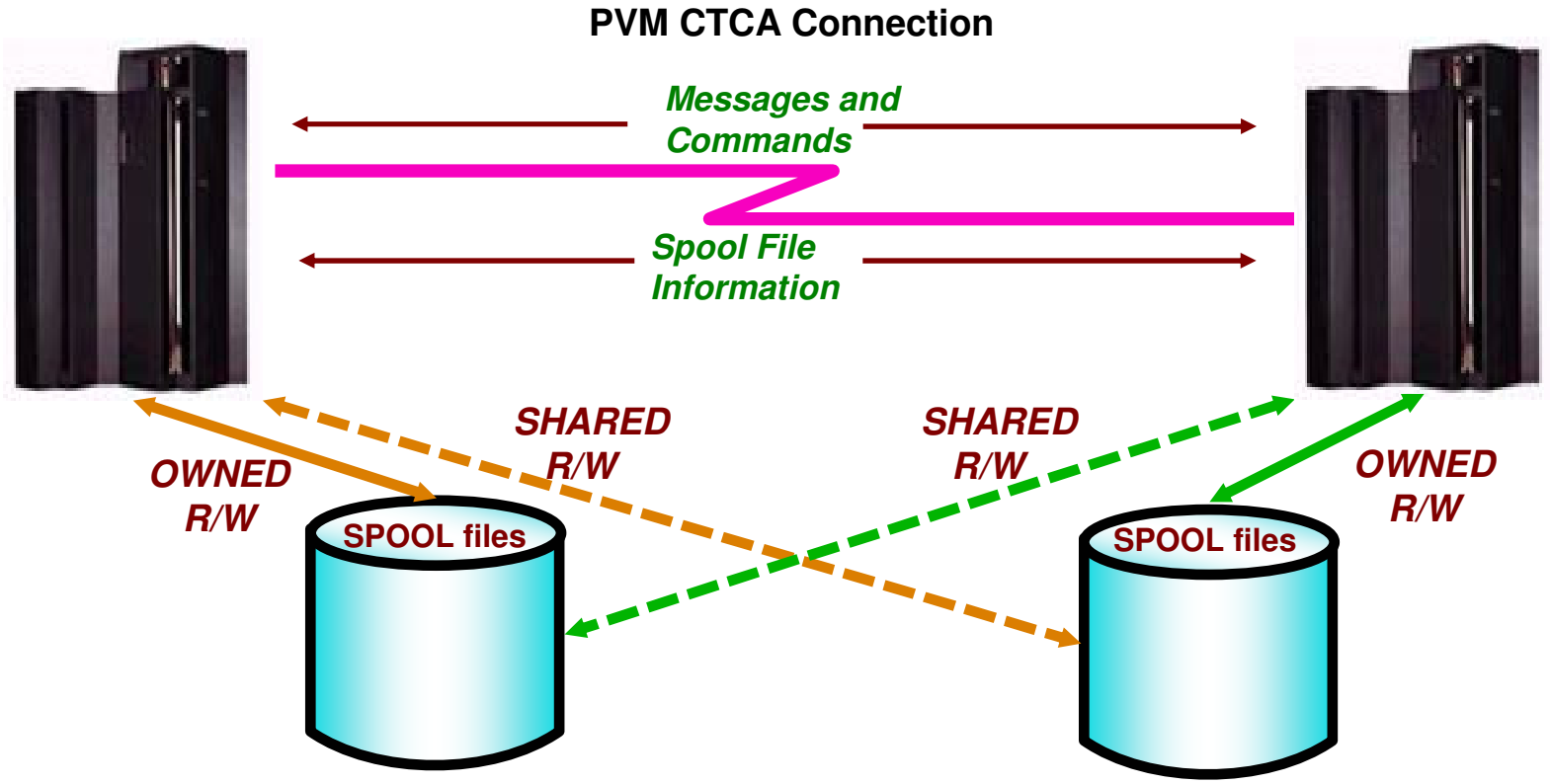
Shared Minidisk Volumes

- Link control information for all systems is kept on the volume

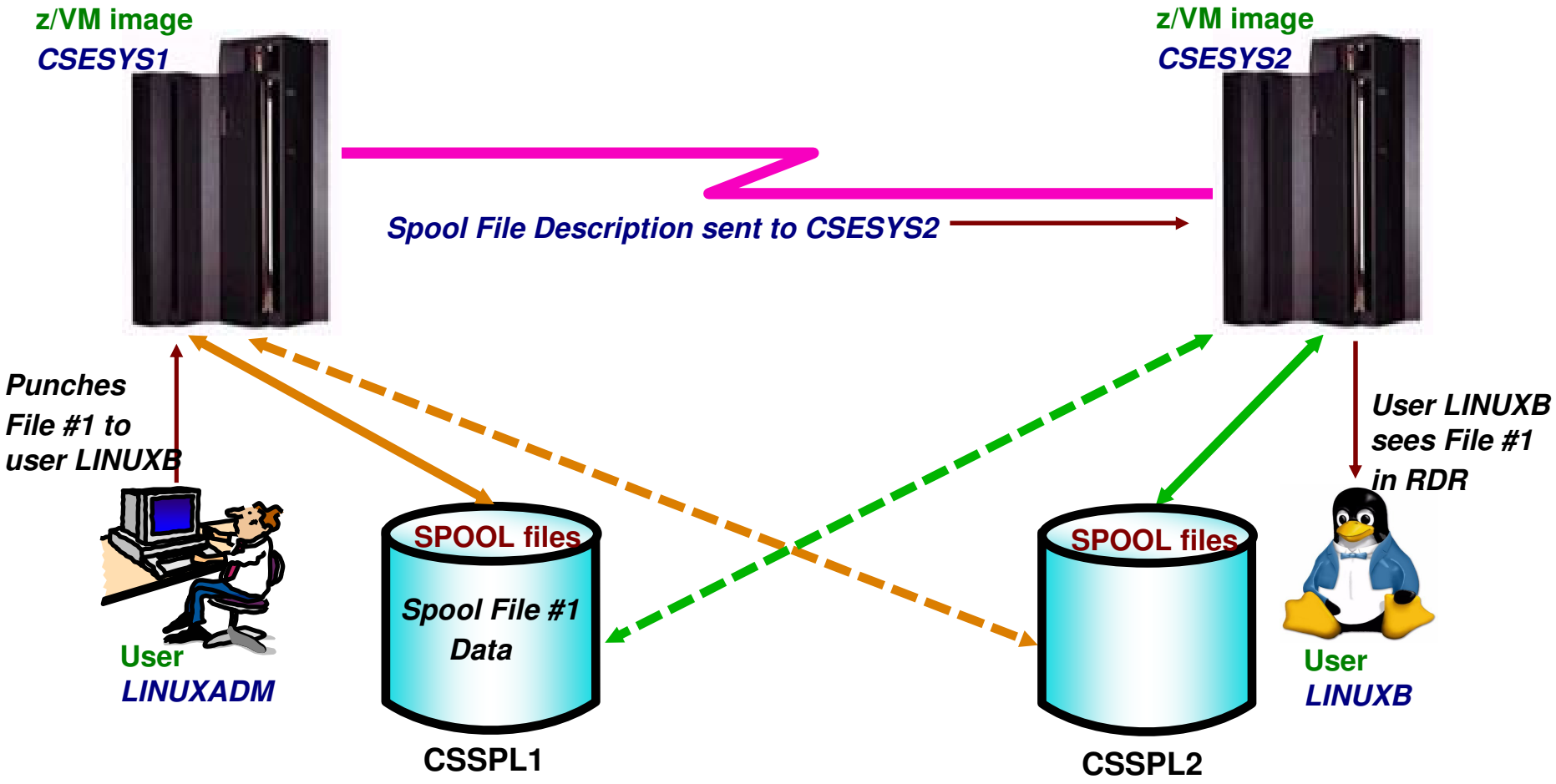


CSE Communication and Spool

Up to 4 z/VM Images can share spool files



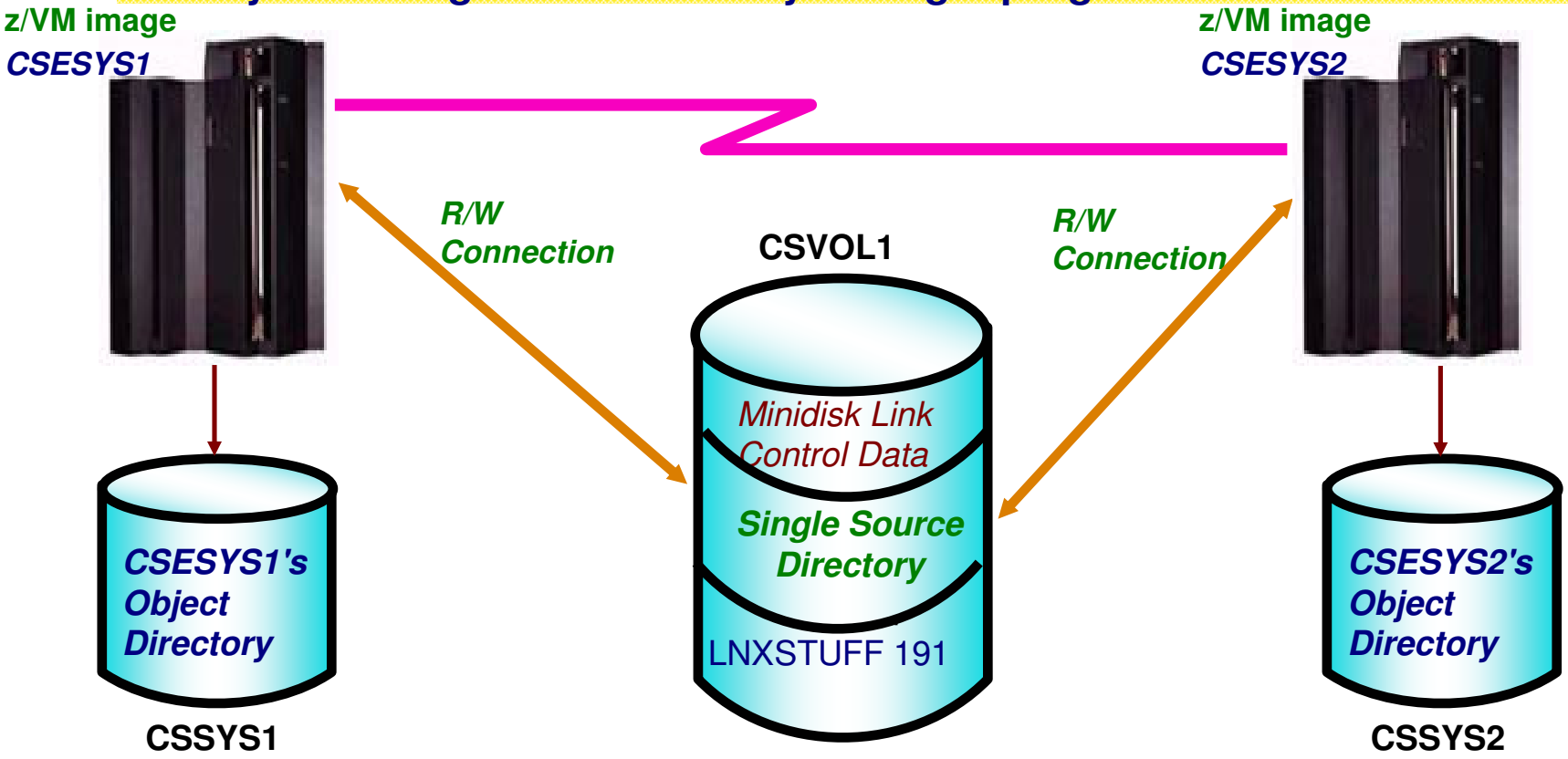
CSE Communication and Spool …



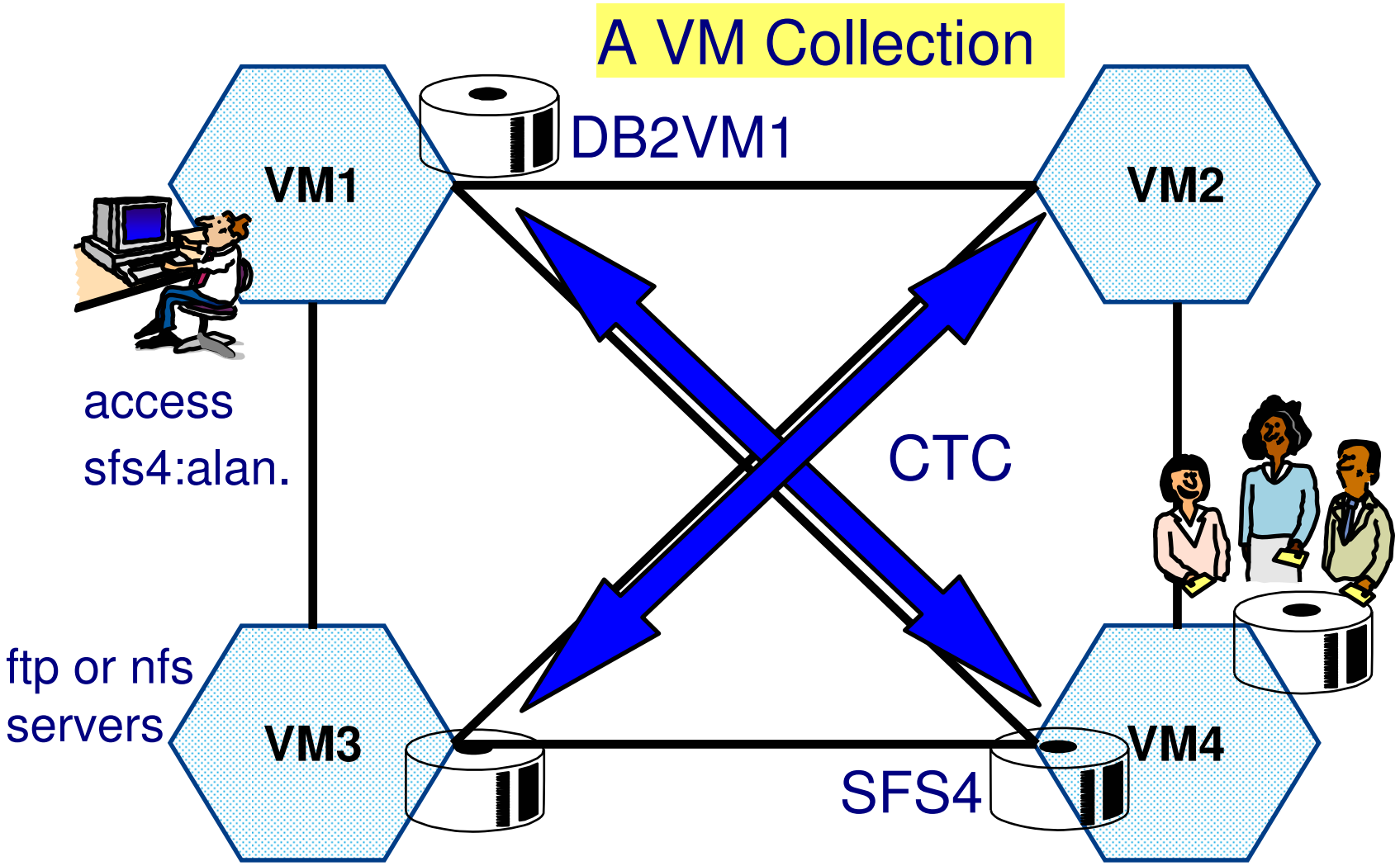
CSE Single Source Directory

All systems use the same source directory

- Each system has its own object directory
- May be managed with directory manager program such as DirMaint



Inter-System Facility for Communications



“TRACK” Diagnose

- TRACK tool originally from Princeton (Serge Goldstein) now maintained by Nationwide (Jim Vincent)
- z/VM 5.2 storage management changes provided motivation to dispense with TRACK’s use of LOCK, DISPLAY HOST, and Diagnose 4 (Examine Real Storage)
  - Proposed Diagnose interface to enable authorized guest to gain access to target’s base address space or System Execution Space as a data space
    - Natural use by exploiting Access Register mode
  - Code written but serialization issues never resolved => not released
  - Turned out to be useful for guest migration (with extension to allow read-only or read/write access to target’s address space)

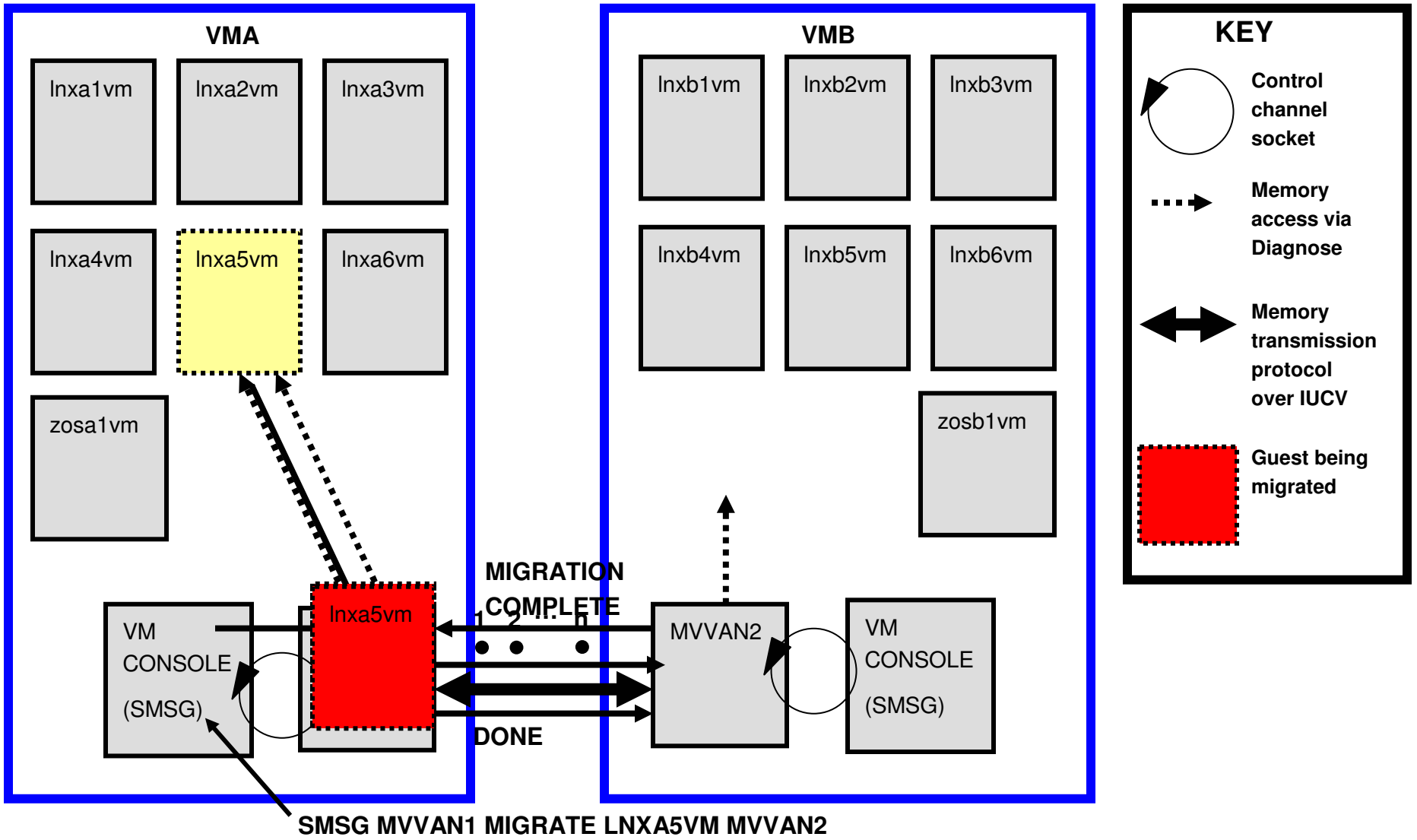
Migration Diagnose

- **Migrator interface to CP functions**
  - **Begin migration (outward or inward)**
  - **Get guest configuration**
  - **Set guest configuration**
  - **Retrieve migration change bits**
  - **Stun guest**
  - **Get guest state**
  - **Restore guest state**
  - **Abort migration**

Guest Memory Change Tracking

- **Initiated by Migration Diagnose "Begin outward migration" function**
  - **Causes target guest key operations to be intercepted**
  - **Keeps shadow copy of page change state for migration**
- **First invocation of "Retrieve migration change bits" returns a "1" bit for each non-zero target guest page and resets all migration change bits**
- **Subsequent invocations clear migration change bits and return a "1" bit for each page changed since last invocation**

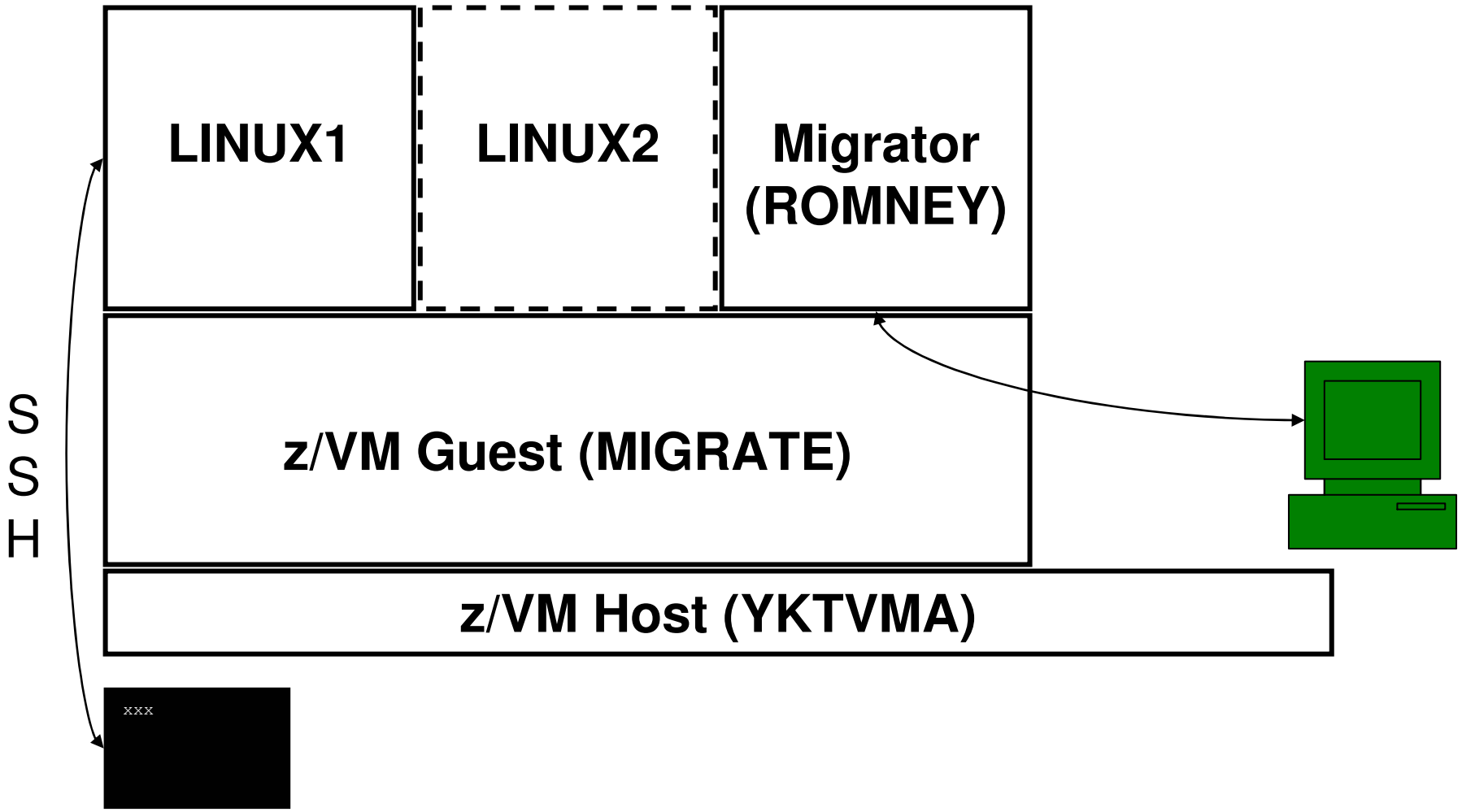
Conceptual Migration Process



Technology Demonstration

- **Configuration**
- **Caveats**
- **Problems**
- **Demo**

Technology Demonstration - Configuration



Technology Demonstration - Caveats

- This is a proof-of-concept
  - Same system still presents most challenges
  - Simpler to set up, control, and demonstrate
  - Guests are only 256MB
  - Not speed team moving van – REXX program orchestrates migration using functions that invoke Track and Migration Diagnoses
- Using a different user identifier is merely a convenience
  - Facilitates testing
  - Does not affect other aspects of migration
- Invocation via SMSG or as a CP command is well understood
  - Some additional considerations (e.g., serialization of requests) will have to be made

Technology Demonstration - Problems

- **Brief but inconvenient pause (PING) after migration completes and network interface reset**

Technology Demonstration

Challenges

- Release-to-release compatibility
- Existing CSE and ISFC customer environments
- Processor architecture and features
  - E.g., System z9 to z990
- CSE and ISFC duplication
  - Collection definition
  - Communication
- Distance
  - Shared I/O subsystem
- User name space
- Migration eligibility
  - Some current restrictions will disappear
  - Others will need to be removed

Summary

- **Multi-system virtualization on System z is feasible**
  - **Need to define objectives**
  - **Requires staged delivery plan**
- **We have a guest migration prototype**
  - **Work needed to make the function production-ready**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