z/VM Live Guest Migration

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IBM System z Software – Strategy and Design
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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

1. LINK LNXSTUFF 191 291 MR
   - Linked R/W

2. LINK LNXSTUFF 191 291 MR
   - Linked R/O
CSE Communication and Spool

**Up to 4 z/VM Images can share spool files**

PVM CTCA Connection

- **Messages and Commands**
- **Spool File Information**

SPOOL files

- **OWNED R/W**
- **SHARED R/W**

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CSE Communication and Spool ...

- z/VM image CSESYS1
- z/VM image CSESYS2

Spool File Description sent to CSESYS2

- Punches File #1 to user LINUXB
- User LINUXADM
- User LINUXB sees File #1 in RDR

SPOOL files
- Spool File #1 Data
- CSSPL1
- CSSPL2

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

- VM1
- VM2
- VM3
- VM4
- DB2VM1
- CTC
- SFS4
- A VM Collection

- access sfs4:alan.
- ftp or nfs servers
“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

VMA

Inxa1vm
Inxa2vm
Inxa3vm
Inxa4vm
Inxa5vm
Inxa6vm
zosa1vm

VM CONSOLE (SMSG)

VMB

Inxb1vm
Inxb2vm
Inxb3vm
Inxb4vm
Inxb5vm
Inxb6vm
zosb1vm

MVVAN2

VM CONSOLE (SMSG)

KEY

Control channel socket
Memory access via Diagnose
Memory transmission protocol over IUCV
Guest being migrated

SMSG MVVAN1 MIGRATE LNXA5VM MVVAN2

MIGRATION COMPLETE

DONE
Technology Demonstration

- Configuration
- Caveats
- Problems
- Demo
Technology Demonstration - Configuration

- LINUX1
- LINUX2
- Migrator (ROMNEY)
- z/VM Guest (MIGRATE)
- z/VM Host (YKTVMA)
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 128MB
  - 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