z/VM Live Guest Migration

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Romney White
romneyw@us.ibm.com
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

User LINUXA

z/VM image CSESYS1

Minidisk Link Control Data

CSVOL1

2. LINK LNXSTUFF 191 291 MR
Linked R/O

User LINUXB

z/VM image CSESYS2

R/W Connection

Shared Minidisk Volumes

Cross-System LINK
CSE Communication and Spool

Up to 4 z/VM Images can share spool files

PVM CTCA Connection

Messages and Commands

Spool File Information

OWNED R/W

SHARED R/W

SHARED R/W

OWNED R/W
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

z/VM image
CSESYS1

z/VM image
CSESYS2

R/W Connection
CSVOL1

R/W Connection

Minidisk Link
Control Data

Single Source Directory

LNXSTUFF 191

CSESYS1's Object Directory

CSSYS1

CSESYS2's Object Directory

CSSYS2
Inter-System Facility for Communications

A VM Collection

VM1

DB2VM1

VM2

CTC

VM3

SFS4

VM4

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

VMB
- Inxb1vm
- Inxb2vm
- Inxb3vm
- Inxb4vm
- Inxb5vm
- Inxb6vm
- zosb1vm

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
  - No 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
  - More work needed to make the function production-ready