Neel Shah **CSCI-4342**
Writing 1 **09/11/2016**

Overview, Key Words, and Subtopic Name:
This product improves scalability, reliability, and security in the cloud by providing new features to a pre-existing add-on, Remus, for the Xen hypervisor. Particularly, this enhancement will provide the ability to manage and maintain state between a cluster of virtual machines (VM) upon a system or security fault and it will enable system checkpointing upon specified events. This product will be beneficial to any entity who utilizes and trusts the cloud to handle their operations.
Keywords: cloud, scalability, reliability, security, virtualization
Subtopic: Cloud reliability and security

Intellectual Merit:
The Small Business Innovation Research Phase I project will provide new methodologies to assure uptime and integrity in cloud systems. Remus already checkpoints and reverts VMs upon faults. Extending this ability such that a cluster of interdependent VMs can be managed, backed up, and restored without disrupting network and filesystem state will be a challenge. With the need to revert many VMs, the time it takes to complete one network or filesystem transaction can increase. Since we do not know where or when in the cluster a fault will occur, it will be a challenge to account for and mitigate time lost due to maintaining cluster state upon a system restore. Also, more efficient checkpointing methods need to be implemented upon the addition of system event based checkpointing.
Upon project completion, the Remus extension for the Xen hypervisor should now be able to protect a cluster of interdependent VMs. If there is a fault in one or many VMs, Remus will revert failed VMs to a known good checkpoint, switch execution to their backup VMs, and it will then assure the network and filesystem state of the remaining VMs is not corrupted after handling a change in cluster topology. Also, Remus will be able to checkpoint VMs if certain predefined events occur on a system. This will enable a more fine grained fault mitigation policy in the individual VM or the cluster of VMs.
To achieve these goals, Remus must first be modified to protect a cluster of VMs in a naïve way, where the entire cluster is rolled back upon a fault in an individual VM. Then, Remus will be extended to efficiently manage cluster state with minimal restores upon a single system fault. Furthermore, after research on the importance and meaning of many system events, Remus will be responsible for monitoring each VM in the cluster for the selected events.

Broader/Commercial Impact:
This innovation will make “the cloud” more reliable. Any entity that leverages the cloud to handle their operations trusts that their resources are always performing without faults to assure a high quality of service. In the perspective of a service provider, the fabric in which they distribute their service is critical in defining the service’s quality. These additions to Remus enables the cloud to scale more efficiently, handle faults better to become more reliable, and have greater system visibility to determine integrity.

This page defines the separation from my old senior design project idea to my new one.

Neel Shah **CSCI-4342**
Writing 1 - Redo **09/25/2016**

Overview, Key Words, and Subtopic Name:
This product accounts for the advent of Internet of Things (IoT) and cloud computing by bringing a new feature to the Xen hypervisor. This new feature emulates Intel's Rack Scale Architecture (RSA) through a software front instead of a hardware one. RSA is a model where one operating system, a virtualized one, can share the hardware resources of other machines to provide one "super" operating system. Mainly, individuals who manage data centers and cluster would benefit from this product since it enables them to design flexible computing fabrics that enable quick and dynamic server configurations to account for incoming workload to scale efficiently.
Keywords: rack scale architecture, virtualization, memory management, internet of things, cloud computing
Subtopic: Rack Scale VMs through a software fabric

Intellectual Merit:
The Small Business Innovation Research Phase I project will provide facilities for data center administrators to create flexible server architectures to account for the rapid growth of the IoT paradigm. This growth coupled with the advent of cloud computing pushes data center administrators to constantly rethink their server architecture to account for dynamic workloads. Currently, resources in a data center are locked at the individual server level. Computing workloads will change with the aforementioned trends, thus requiring resources to adapt for them. Some data centers are unable to upgrade hardware as frequently as their workloads change. This increases strain hindering the data center incapable of efficiently adapting to the new workloads. Furthermore, RSA is typically achieved by hardware solutions. Products such as remote direct memory access (RDMA) enabled network cards and switches are required to enable sharing of computing resources across hosts.
This software solution to rack space architecture through the Xen hypervisor enables data centers to bring flexibility to existing hardware. Administrators can specify one master virtual operating system to share the resources within a specified computing pool. The master operating system will use intelligent algorithms to share and balance memory throughout the pool.

Broader/Commercial Impact:
This innovation will provide facilities for commodity data centers or data centers who are unable to account for modern workloads to reliably scale. IoT and cloud computing are paradigms that are taking over the industry. A multitude of businesses are choosing the two as their main service provider. With this shift, there needs a way for the service provider backend, a data center, to reliably adapt to new workloads. RSA is the solution for this, but it is difficult to attain solely through hardware. This innovation provides the solution through a software fabric which is easy to adapt in data centers that are unable to reorganize resources or upgrade hardware.

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Writing 2 **09/25/2016**

The computing industry is showing trends where developers pursue “Internet of Things” (IoT) and cloud computing. With this movement, service providers need to adapt their hardware to account for the new trend. When many businesses choose IoT devices as their main interface with customers and the cloud as their main backend service provider, they expect data centers to reliably handle all traffic related to their service.

Currently, Intel estimates that the number of IoT devices will reach upwards of 30 billion by 2020. These devices will be communicating with “the cloud” in a data center to provide a service. If data centers are unable to economically adapt to this new workload, then the business will suffer due to a poor quality of service.

Data centers need to constantly adapt to handle this new workload. In most data centers, hardware resources are pinned to individual servers. Data centers are also unable to upgrade resources within individual servers. Virtualization and trends of cloud computing adapt for newer workloads, but suggest that many virtual machines work together to solve simple problems. These problems are simple enough for one operating system, or one virtual machine, to solve, but the singular virtual machine might not enough hardware resources to process the workload. Having many virtual machines over complicates the service model and increase upkeep costs. The simplicity of one virtual machine that is powerful enough to handle the workload would decrease management costs.

Rack scale architecture (RSA) intends on providing a solution to this by giving one operating system access to other servers’ hardware. Intel is a leader in developing this architecture, but their solution requires administrators to change server organization and install specialized hardware. This hardware becomes really expensive, thus making the optimized data center layout unreachable for most consumers.

This innovation brings the novelty of Intel’s RSA solution, but through a solely software solution. Leveraging the open source Xen hypervisor, this product provides a virtual machine to share resources of other physical servers. With it, the data center administrator will be able to select specific physical machines to be places within a conceptual resource pool which the master virtual machine can share resources from.

Specifically, this product focuses on providing intelligent memory management algorithms across physical servers. Traditionally, memory is shared across servers using remote direct memory access (RDMA) enabled network interfaces. These can be expensive. Using Bitdefender’s virtual machine introspection library, libbdvmi, the Xen hypervisor will be able to monitor when the master virtual machine tries to access data from a “remote” page of memory. Then, the hypervisor will be able to copy memory from the remote physical machine into the virtual machine. Furthermore, Xen will be responsible for intelligently mapping memory least used into remote physical machines while keeping the most used memory local to the virtual machines physical host. With this, the virtual machine will not suffer from the costs of retrieving and copying memory from a remote host as much as it could.

This innovation provides mechanisms to handle new workloads that IoT and cloud computing bring.