Hee Won Lee

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EDUCATION

North Carolina State University, Raleigh, North Carolina, USA

- Ph.D. in Computer Science — Aug 2009 – May 2015
  - Thesis: Network Emulation with Adaptive Time Dilation
  - Adviser: Prof. Mihail L. Sichitiu, Co-adviser: Prof. David Thuente
  - Concentration: Virtualization, Networked System, Distributed System

Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

- M.E. in Software Engineering — Aug 2004 – Aug 2005

Korea University, Seoul, South Korea

- B.E. in Electrical Engineering — Mar 1995 – Feb 2002

PROFESSIONAL EXPERIENCES

Samsung Electronics, Hwaseong-si, Gyeonggi-do, South Korea

- Principal Engineer/Head of Group — Dec 2020 – Present
  - I am leading Cloud Platform Group (50+ software/system engineers) in Data & Information Technology Center
    - Building an on-premise cloud platform (IaaS/Paas/SaaS) for Samsung Electronics
    - Transforming Samsung's supercomputers into cloud services

AT&T Labs Research, Bedminster, New Jersey, USA

- Principal Inventive Scientist — Mar 2015 – Jul 2020
  - 2019–2020
    In-Memory Database & Kubernetes
    - Designed and implemented Redis High Availability with Kubernetes in CI/CD environment
    - Integrated Redis HA helm charts into Radio Access Network Intelligent Controller release 4 (field trial version)
    - Evaluated the performance of Redis with Intel Optane Persistent Memory
    - Analyzed cost benefits by applying Intel Optane Persistent Memory to AT&T's Content Delivery Network (CDN)
    - Evaluated and compared the performance of *Redis* vs *Aerospike* vs *Cassandra* using the YCSB benchmark tool
  - 2017–2018
    Software-Defined Storage
    - Designed and implemented containerized Ceph with Kubernetes helm charts
    - Performed extensive resiliency tests for containerized Ceph storage with Kubernetes
    - Developed best recovery practices from various failure scenarios for containerized Ceph storage with Kubernetes
    - Evaluated the performance of page cache & dm-cache in virtualized environments
    Advanced storage networking for ultra low latency with RDMA
    - Set up a testbed for NVMe over Fabrics with CPU offloading on RoCE-based lossless networks
    - Evaluated the performance and verified zero CPU usage on the target host machine
  - 2015–2016
    Multi-site Network Traffic Shaper for Quality of Service
    - Designed and implemented a system that controls network bandwidth/delay between multi-site OpenStack clusters
    - Opensourced the code at https://github.com/att/netarbiter
- Intern — May 2014 – Aug 2014
  - Designed and implemented I/O traffic protection mechanisms for cloud storage

North Carolina State University, Raleigh, North Carolina, USA

- Research Assistent — Jan 2010 – Dec 2014
  - Designed and implemented a virtualization platform for evaluating distributed applications running on diverse OSs (Linux, FreeBSD, Windows, JunOS)
  - Redesigned and customized the QEMU-KVM hypervisor to synchronize distributed VMs with virtual time

KT Corporation (Korea Telecom), Daejeon, South Korea

- Software Engineer — Jan 2002 – Jul 2009
  - 2008–2009
    Capacity Planning for KT Backbone Network and IPTV Services
    - Built a virtual network environment of KT backbone networks using OPNET simulation tool
    - Created flow traffic based on link loads of KT backbone networks
    - Performed link capacity planning for IPTV services

- 2005–2007
  VoIP Network Management System
  - Conducted requirement management and then designed architecture of VoIP-NMS
  - Led a development team of VoIP-NMS
  - Deployed VoIP-NMS to production
- 2002–2004
  IP Core Network Management System
  - Designed and implemented a system component that collects network equipment information from MIB (Management Information Base) using SNMP (Small Network Management Protocol)
  - Developed SQL scripts for Oracle database
  - Developed a system component that exchanges information with Service Assurance System using XML-RPC
  - Set up an MPLS testbed using Cisco Routers 7204/7500, Juniper Router M5 and Ixia Traffic Generator

PUBLICATIONS

CONFERENCES

[8] **TIPS: Making Volatile Index Structures Persistent with DRAM-NVMM Tiering**.
Madhava Krishnan, Wook-Hee Kim, Xinwei Fu, Sumit Kumar Monga, Hee Won Lee, Minsung Jang, Ajit Mathew, and Changwoo Min.
In *USENIX Annual Technical Conference (ATC 2021)*.
Virtual Event, Jul 2021.

[7] **eMRC: Efficient Miss Ratio Approximation for Multi-Tier Caching**.
Zhang Liu, Hee Won Lee, Yu Xiang, Dirk Grunwald, and Sangtae Ha.
In *USENIX 19th Conference on File and Storage Technologies (FAST 2021)*.
Virtual Event, Feb 2021.

[6] **EF-Dedup: Enabling Collaborative Data Deduplication at the Network Edge**.
Shijing Li, Tian Lan, Bharath Balasubramanian, Moo-ryong Ra, Hee Won Lee, and Panta Rajesh.
In *IEEE 39th International Conference on Distributed Computing Systems (ICDCS 2019)*.
Dallas, TX, USA, Jul 2019.

[5] **Fighting with Unknowns: Estimating the Performance of Scalable Distributed Storage Systems with Minimal Measurement Data**.
Moo-ryong Ra and Hee Won Lee.
In *IEEE 35th Symposium on Mass Storage Systems and Technologies (MSST 2019)*.
Santa Clara, CA, USA, May 2019.

[4] **MIST: Mitigating Host-Side Interference for Storage Traffic in Virtualized Data Centers**.
Hee Won Lee and Moo-ryong Ra
In *IEEE 9th International Conference on Cloud Computing (CLOUD 2016)*.
San Francisco, CA, USA, Jun 2016.

[3] **Integrated Simulation and Emulation using Adaptive Time Dilation**.
Hee Won Lee, David Thuente, and Mihail L. Sichitiu.
In *ACM 2nd SIGSIM Conference on Principles of Advanced Discrete Simulation (PADS 2014)*.
Santa Clara, CA, USA, May 2014.

[2] **Resource Management System for Next Generation Services**.
Seung-Hee Han, Bom-Su Kim, Chan-Kyou Hwang, Hee Won Lee, Byung-deok Chung.
In *IEEE International Conference on Advanced Technologies for Communications 2019*.
Hai Phong, Vietnam, Oct 2009.

[1] **Reusability Enhancement by Using Flexible Topology Architecture for Network Management System**.
Hee Won Lee, Chan Kyou Hwang, Jae-Hyoung Yoo, Ho-Jin Choi, Sungwon Kang, and Dan H. Lee.
In *IEEE/ACIS 7th International Conference on Computer and Information Science (ICIS 2008)*.
Portland, Oregon, USA, May 2008.

JOURNALS

[3] **FPV Video Adaptation for UAV Collision Avoidance**.
Simran Singh, Hee Won Lee, Tuyen X. Tran, Yu Zhou, Mihail L. Sichitiu, Ismail Güvenç, and Arupjyoti Bhuyan.
IEEE Open Journal of the Communications Society, vol. 2, pp. 2095–2110.
Aug 2021.

[2] **Network Link Emulation With Adaptive Time Dilation**.
Hee Won Lee, Mihail L. Sichitiu, and David Thuente.
Journal of Parallel and Distributed Computing, vol. 104, pp. 88–98.
Jun 2017.

[1] **High-performance Emulation of Heterogeneous Systems using Adaptive Time Dilation**.
Hee Won Lee, Mihail L. Sichitiu, and David Thuente.
International Journal of High Performance Computing Applications, vol. 29, issue 2.
May 2015.

WORKSHOPS, POSTERS AND TECHNICAL REPORTS

[3] **Accelerating Applications in the Fast-Moving Devices with Proactive Provisioning (Poster)**.
HyunJong Lee, Hee Won Lee, Moo-Ryong Ra, Yu Xiang, and Jason Flinn.
In *Proceedings of the 17th Annual International Conference on Mobile Systems, Applications, and Services (MobiSys 2019)*.
Seoul, South Korea, Jun 2019.

[2] **IOArbiter: Dynamic Provisioning of Backend Block Storage in the Cloud**.
Moo-Ryong Ra and Hee Won Lee.
arXiv preprint arXiv:1904.09984.
Apr 2019.

[1] **End-User IPTV Traffic Measurement of Residential Broadband Access Networks**.
Young J. Won, Mi-Jung Choi, Byung-Chul Park, James W. Hong, Hee Won Lee, Chan Kyu Hwang, and Jae-Hyoung Yoo.
In *IEEE Network Operations and Management Symposium (NOMS) Workshops*.
Apr 2008.

PATENTS

ISSUED

[10] **Dynamic Provisioning of Storage in the Cloud**.
Moo-ryong Ra and Hee Won Lee.
US 10,530,703 B2.
Date of Patent: January 7, 2020.

[9] **Method and Apparatus for Detecting Abnormal Call Surging through Call Counts**.
Hee Won Lee, Seong-Ju Kim, Seung-Hee Han, Chan Kyou Hwang, Jae-Jin Lee, Bom-Su Kim and Young-Dae Kim.
KR 10-1465244 B1.
Date of Patent: November 19, 2014.

[8] **Method for IP-based Broadcasting Advertisement using Zapping Time**.
Young-Dae Kim, Chan Kyou Hwang, Jae-Hyoung Yoo, Hee Won Lee, S. Yoon and Bom-su Kim.
KR 10-1383292 B1.
Date of Patent: April 1, 2014.

[7] **Apparatus and Method for Enhancing Reusability of Software Component**.
Hee Won Lee and Chan Kyou Hwang.
KR 10-1311515 B1.
Date of Patent: September 16, 2013.

[6] **Apparatus and Method for Displaying Network Faults using Integrated Topology**.
Hee Won Lee and Chan Kyou Hwang.
KR 10-1229569 B1.
Date of Patent: January 29, 2013.

[5] **Network Management Apparatus and Method, User Terminal, and Recording Medium**.
Seong-Ju Kim, Chan Kyou Hwang, Hee Won Lee, Jae-Jin Lee and Young-Dae Kim.
KR 10-1065800 B1.
Date of Patent: September 9, 2011.

[4] **Method for Sending Fault and Fault Correction Information from Network Management System to Other Systems using Database as Queue**.
Hee Won Lee and Ki-eung Kim.
KR 10-1043165 B1.
Date of Patent: June 14, 2011.

[3] **System and Method for Providing Video Advertisement**.
Young-Dae Kim, Chan Kyou Hwang, Jea-Hyoung Yoo, Hee Won Lee, S. Yoon and Bom-Su Kim.
KR 10-1394611 B1.
Date of Patent: June 14, 2011.

[2] **Fault Management Method and Apparatus for Reduction of Response Time and Improvement of Handling Preciseness**.
Bom-Su Kim and Hee Won Lee.
KR 10-0950766 B1.
Date of Patent: March 25, 2010.

[1] **Work Logic Distributed System and Method**.
Hee Won Lee.
KR 10-0941752 B1.
Date of Patent: February 3, 2010.

SOFTWARE SYSTEM EXPERIENCES

Storage

- Persistent Memory 2019 – 2020
  - Set up a testbed with Intel Optane Persistent Memory (in collaboration with Intel team)
  - Analyzed the performance characteristics of Intel Optane Persistent Memory
  - Measured the latency of Redis with Intel Optane Persistent Memory using the *memtier_benchmark* tool
  - Designed a framework that converts volatile indexes into their persistent counterparts for Persistent Memory
- Distributed Storage System 2015 – 2018
  - Designed and implemented containerized Ceph with Kubernetes helm charts with an one-osd-per-pod approach
  - Evaluated the performance of Ceph with dm-cache
  - Characterized the performance of multi-tier caching in Ceph storage (host/vm page cache, rbd cache, ceph cache-tier)
  - Evaluated and compared the performance of SATA SSD and NVMe SSD
  - Designed a system architecture for making a commodity SSD array a usable iSCSI block storage backend for OpenStack clusters
  - Designed and implemented the backend of OpenStack Cinder for dynamic configuration and QoS support
- I/O Traffic Protection [Python] 2014
  - Designed and implemented an I/O bandwidth reservation algorithm that guarantees the minimum I/O bandwidth of a virtual host connected to a shared storage volume through iSCSI
  - Designed a NUMA-aware CPU pinning algorithm that protects I/O traffic from CPU interference
  - Evaluated the system performance for diverse types of I/O pattern using FIO and Filebench

Networking

- RDMA over Converged Ethernet (RoCE) 2017
  - Set up a testbed for lossless RoCE using PFC-capable Mellanox Spectrum Switch and Dell servers equipped with ConnectX-5 NICs
  - Evaluated the performance of NVMe over Fabric for zero CPU usage on target host machine
- Network Traffic Controller [Ansible] 2016
  - Designed and implemented a system that controls network bandwidth/delay between OpenStack clusters using Tc/NetEm
- Network Link Emulation [C++, Python] 2014
  - Interconnected distributed VMs through virtual links using Tc/NetEm with adaptive time dilation
- Software-Defined Networking [Python] 2012
  - Used OpenFlow POX controller and Open vSwitch to migrate VirtualBox-based virtual networks
- Routing Algorithms [Java] 2012
  - Implemented modified Dijkstra's algorithm with negative weights
  - Implemented vertex/edge disjoint paths and elementary circuits search algorithms
  - Implemented CPLEX code with Integer Linear Programming for Routing and Wavelength Assignment
- Queueing Systems [Java] 2010
  - Implemented discrete event simulation models for queuing systems (M/M/1, M/M/m, M/G/m)
- Wireless Networking [C++] 2010

- Designed and implemented an OMNeT++ model for IVG (Inter-Vehicle Geocast) routing protocol in vehicle-to-vehicle ad-hoc network simulation
- Connected KVM-based virtual nodes through a wireless simulation model of OMNeT++

▪ Peer-to-Peer File Sharing System [Java] 2009
- Mapped a file signature (created by encoding text document with m-bit string) onto a hash space
- Used Apache Mina, Apache FtpServer, and JavaDB

CPU & Memory

▪ CPU/Memory Control [Python] 2014
- Designed and implemented a CPU/Memory control algorithm that enforces CPU/Memory ceiling and allocates a relative share of CPU time using Linux Control Groups (Cgroups)

▪ Multi-Threading [C++] 2014
- Created a thread for searching text file paths and multiple worker threads for counting words using Boost Filesystem and Thread Libraries
- Implemented multiple producer, multiple consumer thread-safe queue and map

▪ Prioritized Preemptive Schedulers [C] 2013
- Implemented a prioritized preemptive scheduler using POSIX thread library
- Designed and implemented a priority-based scheduling algorithm using XINU kernel (a small UNIX OS)

▪ Demand Paging [C] 2013
- Implemented a demand paging system that allows for more address space than physically available one (XINU)

Virtualization & Simulation

▪ Hybrid Simulation and Emulation System [C++, Python] 2014
- Built an integrated simulation (NS-3) and emulation (QEMU-KVM) framework in a distributed environment

▪ Virtual Time Synchronization [C++] 2014
- Designed and implemented a spinlock on shared memory to synchronize distributed VMs (processes created by KVM hypervisor) and simulation nodes (processes created by NS-3) with virtual time
- Implemented a virtual time synchronization daemon with TCP/UDP sockets using Boost Asio Library

▪ High-Performance Emulation System [C++, Python] 2010 – 2013
- Emulated higher performance with a time dilation technique using unmodified OSs (Linux, FreeBSD, Windows, and Junos) and real application workloads (VLC media player)
- Modified the QEMU-KVM hypervisor for virtual time

RESEARCH MENTORING

▪ **Simran Singh**, North Carolina State University
- Project: UAV real-time video applications with cellular infrastructure support
- 2019 fall internship at AT&T

▪ **Madhava Krishnan**, Virginia Tech
- Project: A general purpose in-memory key-value store architecture for emerging persistent memory
- 2019 summer internship at AT&T

▪ **HyunJong (Joseph) Lee**, University of Michigan–Ann Arbor
- Project: Predictive migration of edge computations
- 2018 summer internship at AT&T

▪ **Zhang Liu**, University of Colorado–Boulder
- Project: Multi-tier cache orchestration with miss ratio curve
- 2017 summer internship at AT&T

HONORS & AWARDS

▪ **Outstanding Teaching Assistant**, North Carolina State University Apr 2011
- Awarded the day of 29 April 2011
  - For excellent service as a teaching assistant during the 2010-11 calender year, the Department of Computer Science recognizes Hee Won Lee as an Outstanding Teaching Assistant
- Teaching Assistent Courses
  - Algorithm (2011)
  - Operating System (2010, 2012, 2013)
  - Computer Networks (2011, 2012)
  - Software Engineering (2010)

▪ **Army Commendation Medal**, U.S. Army Feb 2001
- Awarded an ARCOM (Army Commendation Medal) for dedications and outstanding leadership in U.S. Army

REFERENCES

- **Prof. Mihail L. Sichitiu**
  (PhD Program Advisor during 2010–2015)
  Deaprtment of Electrical and Computer Engineering, North Carolina State University
  890 Oval Drive, 3114 Engineering Building II, Raleigh, NC 27606, USA
  mlsichit@ncsu.edu • +1 (919) 515-7348
- **Dr. Yih-Farn (Robin) Chen**
  (Director during 2015–2020)
  Former Director Inventive Science at AT&T Labs Research
  1 AT&T Way, Bedminster, NJ 07921, USA
  rcccym@gmail.com • +1 (973) 960-1594
- **Dr. Moo-Ryong Ra**
  (Colleague during 2015–2019)
  Former Principal Inventive Scientist at AT&T Labs Research
  Senior Software Engineer at Amazon
  130 Lytton Ave, Palo Alto, CA 94301, USA
  mooryor@amazon.com • +1 (240) 583-0968
- **Prof. Sangtae Ha**
  (Research Collaborator during 2017–2020)
  Department of Computer Science, University of Colorado Boulder
  ECCR 1B14, 1045 Regent Drive 430 UCB, Boulder CO, 80309, USA
  sangtae.ha@colorado.edu • +1 (303) 492-7031

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