7. CONCLUSION

In resource-constrained embedded systems, such as smartphones, the under-utilized reserved memory is one of the major sources of inefficient resource management. On-demand reservation, which allows the system to exploit the reserved memory during an idle time of owner devices, sheds lights on the way of increasing the performance of the system while guaranteeing devices the use of reserved memory space.

We proposed a novel on-demand reservation approach, named *eCache*, that maximizes the memory efficiency of the system and minimizes the on-demand reservation time for end-user latency. By using the eCache, the system can greatly reduce the number of read I/O operations and increase the launch performance of applications by from 8% to 16%. With this performance improvement, the nature of eviction-based placement spontaneously maximizes the memory efficiency of the system. In addition, the on-demand reservation time can be minimized to millisecond level. This unrecognizable latency may make system more transparent in comparison to the system with the static-reservation approach.

8. ACKNOWLEDGMENTS

This work was supported by the IT R&D program of MKE/KEIT [10041244, SmartTV 2.0 Software Platform] and by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MEST) (No. 2012-0000148)

9. REFERENCES

[1] D. Abramson, J. Jackson, S. Muthrasanallur, G. Neiger, G. Regnier, R. Sankaran, I. Schoinas, R. Uhlig, B. Vembu, and J. W. and. Intel virtualization technology for directed I/O. *Intel Technology Journal*, 10(3)(3), August 2006.

[2] G. Almási, C. Caşcaval, and D. A. Padua. Calculating stack distances efficiently. *SIGPLAN Not.*, 38(2 supplement):37–43, June 2002.

[3] AMD. IOMMU architectural specification. `http://support.amd.com/us/ProcessorTechDocs/48882.pdf`, March 2011.

[4] N. Amit, M. Ben-Yehuda, and B.-A. Yassour. IOMMU: Strategies for mitigating the IOTLB bottleneck. In *Proc. of WIOSCA'10*, 2010.

[5] M. Ben-Yehuda, J. Xenidis, M. Ostrowski, K. Rister, A. Bruemmer, and L. Van Doorn. The price of safety: Evaluating IOMMU performance. In *Proc. of OLS '07*, pages 71–86, July 2007.

[6] Z. Chen, Y. Zhang, Y. Zhou, H. Scott, and B. Schiefer. Empirical evaluation of multi-level buffer cache collaboration for storage systems. In *Proc. of SIGMETRICS '05*, pages 145–156, 2005.

[7] Z. Chen, Y. Zhou, and K. Li. Eviction-based cache placement for storage caches. In *Proc. of USENIX ATC'03*, pages 269–282, Jun 2003.

[8] J. Corbet. Contiguous memory allocation for drivers. `http://lwn.net/Articles/396702/`, July 2010.

[9] W. Enck, P. Gilbert, B.-G. Chun, L. P. Cox, J. Jung, P. McDaniel, and A. N. Sheth. Taintdroid: an information-flow tracking system for realtime privacy monitoring on smartphones. In *Proc. of OSDI'10*, pages 1–6, 2010.

[10] H. Falaki, R. Mahajan, S. Kandula, D. Lymberopoulos, R. Govindan, and D. Estrin. Diversity in smartphone usage. In *Proc. of MobiSys'10*, pages 179–194, 2010.

[11] Gartner. Gartner highlights key predictions for it organizations and users in 2010 and beyond. `http://www.gartner.com/it/page.jsp?id=1278413`, January 2010.

[12] Google. Android open source project. `http://source.android.com/`, 2012.

[13] Google. Nexus s. `http://www.android.com/devices/detail/nexus-s`, 2012.

[14] A. Gutierrez, R. Dreslinski, T. Wenisch, T. Mudge, A. Saidi, C. Emmons, and N. Paver. Full-system analysis and characterization of interactive smartphone applications. In *Proc. of IISWC'11*, pages 81 –90, nov. 2011.

[15] D. Hansen, M. Kravetz, and B. Christiansen. Hotplug memory and the Linux VM. In *Proc. of OLS '04*, 2004.

[16] IDC. Worldwide smartphone market expected to grow 55% in 2011 and approach shipments of one billion in 2015, according to idc. `http://www.idc.com/getdoc.jsp?containerId=prUS 22871611`, June 2011.

[17] J. Jeong, H. Kim, J. Hwang, J. Lee, and S. Maeng. Device-reserved memory as an eviction-based file cache. Technical Report CS-TR-2012-360, Korea Advanced Institute of Science and Technology, July 2012.

[18] J. Jeong, H. Kim, J. Hwang, J. Lee, and S. Maeng. Rigorous rental memory management for embedded systems. *ACM Trans. Embed. Comput. Syst.*, accepted.

[19] G. S. Joachim. Memory efficiency. *J. ACM*, 6(2):172–175, Apr. 1959.

[20] D. Magenheimer, C. Mason, D. McCracken, and K. Hackel. Transcendent memory and linux. In *Proc. of OLS'09*, pages 191–200, 2009.

[21] R. Mattson, J. Gecsei, D. Slutz, and I. Traiger. Evaluation techniques for storage hierarchies. *IBM Systems Journal*, 9(2):78–117, 1970.

[22] R. Mijat and A. Nightingale. Virtualization is coming to a platform near you. `http://www.arm.com/files/pdf/System-MMU-Whitepaper-v8.0.pdf`, 2011.

[23] D. Morrill. Inside the Android application framework. In *Google I/O*, 2008.

[24] M. Nazarewicz. Contiguous memory allocator version 6. `http://lwn.net/Articles/419639/`, December 2010.

[25] Nielsen. The state of mobile apps. `http://blog.nielsen.com/nielsenwire/online_mobile/the-state-of-mobile-apps/`, June 2010.

[26] J. H. Schopp, D. Hansen, M. Kravetz, H. Takahashi, I. Toshihiro, Y. Goto, K. Hiroyuki, M. Tolentino, and B. Picco. Hotplug memory redux. In *Proc. of OLS '05*, 2005.

[27] M. Szyprowski and K. Park. Arm DMA-mapping framework redesign and IOMMU integration. In *Proc. of Embedded Linux Conference Europe*, 2011.

[28] T. M. Wong and J. Wilkes. My cache or yours? making storage more exclusive. In *Proc. of USENIX ATC'02*, pages 161–175, June 2002.