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Architectures for the Future Networks and the Next Generation Internet

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Abstract—Ultra-low power attentive systems with always-on operation and signal monitoring with a disproportionately higher peak performance are now being in high demand, due to the convergence of AI and IoT. In this talk, circuits and architectures to enable exceptionally low power consumption in the common case while achieving high peak performance are discussed for next-generation intelligent systems. Several silicon demonstrations are presented for accelerators, processors and SRAMs with enhanced peak performance above traditionally allowed at nominal voltage, yet at reduced minimum energy. Energy-quality scaling is explored as additional dimension to break the conventional performance-energy tradeoff in error-resilient applications such as AI and vision, from networks on chip to memories and accelerators. Further performance and energy
improvements are discussed through uncommonly flexible in-memory broad-purpose computing frameworks for true data locality, from buffering to signal conditioning and neural net workloads. Finally, challenges and opportunities for the decade ahead are discussed to enable next-generation attentive & intelligent systems withdivergently high peak performance, common-case performance and low minimum power.

Keywords—AI – Artificial Intelligence, IoT – Internet of Things, SRAM – Static Random Access Memory.

1.INTRODUCTION

A new paradigm of architectural design thought of "Clean Slate Design" is being touted against the more traditional approach of incremental design. The theme of "Clean Slate" design is to design the system from scratch without being restrained by the constraints of the existing deployed system, providing a chance to have an unbiased look at the problem space. However, the scale of the current Internet forbids any changes and it is extremely dif- ficult to convince the stake-holders to believe in a clean-slate design and adopt it. There is simply too much risk involved in the process. The only way to mitigate such risks and to appeal to stake holders is through actual Internet-scale validation of such designs showing their superiority over the existing systems. Fortunately, the research fund- ing agencies all over the world have realized this pressing need and a world-wide effort to develop the next generation Internet is being carried out in full throttle. The National Science Foundation (NSF) was amongst the first to announce a GENI (Global Environment for Networking Innovations) program for developing an infrastructure for devel- oping and testing futuristic networking ideas devel- oped as part of its FIND (Future Internet Design) program. The NSF effort was followed suit by the FIRE (Future Internet Research and Experimen- tation) program supporting numerous next genera- tion networking projects under the 7th Framework Program of the European Union, the AKARI pro- gram in Japan and several other similar specialized programs in China, Australia, Korea, and several other parts of the world.

The scale of the research efforts to develop a next generation Internet bears proof to the importance of the Internet and the need for its improvement to sustain the requirements of the future. However, the amount of work being done or proposed may really baffle someone trying to get a comprehensive view of the major research areas. In this paper, it is our goal to help fathom the diversity of these re- search efforts by presenting a coherent model of the research areas and introducing some of the key re- search projects in these areas. However, this paper does not claim to be a comprehensive review of all the next generation Internet projects but may be considered as an introductory treatise on the broad aspects and some related proposed solutions.

II. METHODOLOGY

Methods for developing a “selectively connected” energy efficient network architecture are proposed for study by [2]. Although not particularly simi- lar to DTNs, research in designing selectively con- nected systems could benefit from the existing ideas in DTN’s, particularly when sleep modes of end hosts render an environment of intermittent con- nectivity. The key ideas in the design of selectively connected systems are: (1) Delegation of proxy-able state to assistants that help the end system to sleep,

Policy specifications by the end system to be able to specify particular events for which it should be woken, (3) defining application primitives allow- ing the assistant to participate in the application (e.g., peer-to-peer searches) on behalf of the host and wake up the host only when required, and (4) Developing security mechanisms to prevent unau- thorized access to the systems state from its pat- terns of communication.

The delegation of proxy-able state to the assis- tant and also delegating application responsibilities to it on behalf of the host bear some resemblance to the transfer of custody transfer mechanisms of DTN’s. Nonetheless, custody transfer has the im- plication of defining a paradigm wherein end-to-end principle is not strictly adhered to while it seems that the assistant mechanism simply acts as a proxy for the host for control messages of distributed pro- tocols (thus maintaining selective connectivity) and is authorized to wake up the host whenever actual end-to-end data communication is required. We be- lieve that the design of assistants can be further ex- tended using the concepts of custody transfer and store-and-forward networks such as DTN’s.

Network Monitoring and Control Archi- tectures

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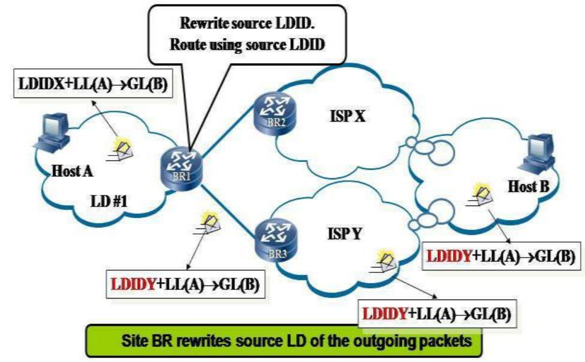

The Internet is a massive distributed system. The success of the Internet can largely be at- tributed to the superiority of the distributed algo- rithms that could handle the scale-up of the In- ternet from a modest research and academic net- work to its present global commercial entity. How- ever, with the commercialization of the Internet, vested economic, political and social interests of the multiple ownership network model have added huge complexities to the elegance and simplicity of the distributed algorithms that were not designed under such constraints. Retrofitting policies into the control plane of distributed algorithms made them complex and often led to instabilities. Sim- ilarly, the management plane of the Internet was never explicitly designed. Management of a single owner, all trusted network of a few hundred hosts did not

pose the requirement of a separate manage- ment plane. With the scale-up of the Internet to its current size, management is no longer a trivial task.

The RANGI project uses similar loca- tor/Identifier split ideas in the context of site multi- homing and traffic engineering. Site multi-homing in the current Internet requires the use of provider independent (PI) addreses which greatly increases the load on default-free-zone (DFZ) routers. While PI sites desire this independance of being able to choose their providers, they negatively impact the scalability of the routing infrastructure. RANGI is an effort to preserve the site interests while at the same time addressing the scalability issue. The pri- mary idea is to assign (1) multiple provider aggre- gatable (PA) addresses to each host in the customer network from upstream provider address blocks, and (2) a host ID representing the logical organiza- tional membership of the host to the customer site. Assigning PA addresses to such stub sites helps the issue of routing scalability, while sites are allowed to multi-home by employing IP re-writing techniques at the border routers. Transport connections are bound to host IDs and, thus, are not affected by address re-writing.

EXPERIMENTAL RESULTS

1.Centralized approach: This is the first phase. Each partner site shall have to fill up a web form manually detailing the testbed de- scriptions and resources available for sharing. This form is provided by a web based search services called Teagle. Users wishing to run an experiment submit the nature of the experi- mental requirements to Teagle. Teagle looks up the repository of testbed meta-data and tries to find a match.

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2.Manual Configuration Approach: In this phase, the partner sites advertise the testbed meta-data by using a specialized middleware and expose a "Infra-structure as a Service (IaaS)" interface [42]. Teagle will search the repository as well as query this service for re- quired resources. In this phase, resources are virtualized and, hence, the IaaS may hide the actual location of a resource from the user pro- viding infrastructure from one or more partner sites.

3.On-Demand Configuration approach: In this final phase of evolution shown in Fig. 42, Teagle will establish an on-demand testbed ac- cording to the user requirement by directly in- teracting with the virtualized resources. Tea- gle provides a best effort configuration and the users need to directly access the resources for complex configurations.

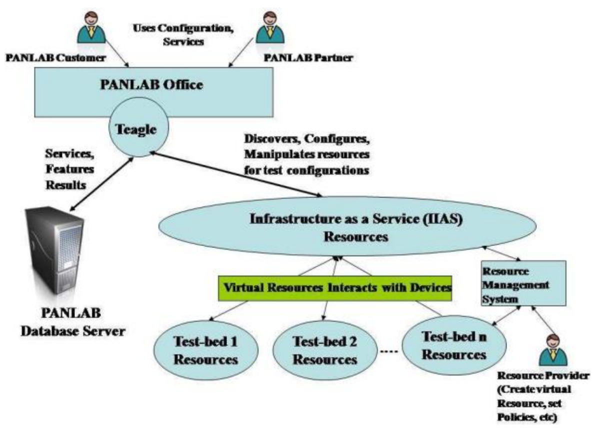

Figure : PANLAB Federation Final Phase: On-Demand Configuration Aproach

PANLAB also proposes the use of IMS (Internet Protocol Multi-media Sub-system) to support the control plane of the federation. PII or PANLAB II is an extension of PANLAB and includes a fed- erated testbed of four core innovative clusters and three satellite clusters[115]. PII takes a more holis- tic view of federation by considering the breadth of technological, social, economical and political con- siderations of the federation.

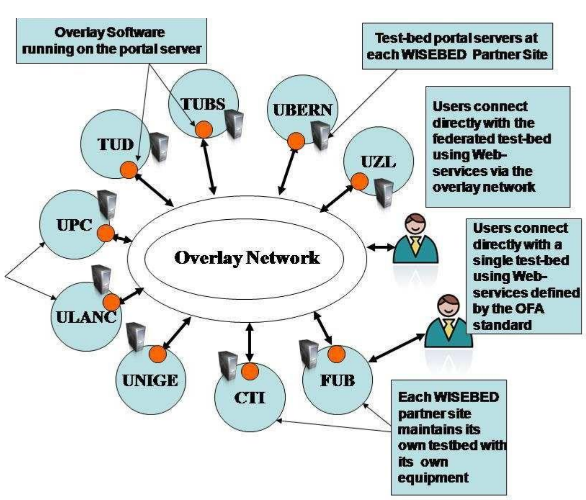

Figure: Overall Architecture of WISEBED Testbed Fed- eration

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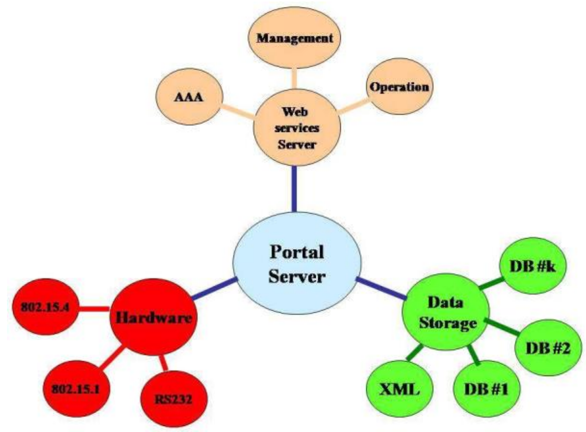

Figure: WISEBED: High Level view of Portal Servers

CONCLUSION

A number of industry and government funding agencies throughout the world are funding research on architecture for future networks that is “clean- slate” and is not bound by the constraints of the current TCP/IP protocol suite. In this paper, we have provided an overview of several such projects. National Science Foundation (NSF) in the United States started a ”Future Internet Design (FIND)” program which has funded a number of architec- tural studies related to clean-slate solutions for vir- tualization, high-speed routing, naming, security, management and control. It also started Global Environment for Network Innovations (GENI) pro- gram that is experimenting with various testbed designs to allow the new architectural ideas to be tested.

Future Internet Research and Experimentation (FIRE) program in Europe is similarly looking at future networks as a part of 7th Framework pro- gram of the European Union (FP7). AKARI pro- gram in JAPAN is also similar. In addition to the above, Internet 3.0 is an in- dustry funded program that takes a holistic view of the present security, routing, and naming, prob- lems rather than treating each of them in isolation. Isolate clean slate solutions do not necessarily fit together since their assumptions may not match. Internet 3.0 while clean-slate is also looking at the transition issues to insure that there will be a path from today’s Internet to the next generation Inter- net.

NSF has realized the need for a coherent architec- ture to solve many related issues and has recently announced a new program that will encourage com- bining many separate solutions into complete archi- tectural proposals. It is to be seen whether the testbeds, which use TCP/IP protocol stacks extensively, being devel- oped today will be able to be used for future Inter- net architectures which are yet to be developed.

In this paper, we have provided a brief descrip- tion of numerous research projects and hope that this will be a good starting point for those want- ing to do future network research or just to keep abreast of the latest developments.

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