**FutureGrid Annual Summary**

FutureGrid is a national-scale Grid, Cloud and HPC computing test-bed service of modest size that includes a number of computational resources at five distributed locations. FutureGrid systems total 4400 cores and provide totally reconfigurable generic nodes with some with special hardware or software. The FutureGrid network is unique and can lend itself to a multitude of experiments specifically for evaluating middleware technologies and experiment management services. This network can be dedicated to conduct experiments in isolation, using a network impairment device for introducing network latency, jitter, loss, and errors to network traffic within FutureGrid. All network links within FutureGrid are dedicated (10GbE lines for all but to Florida, which is 1GbE), except the link to TACC. The significant number of distinct systems within FutureGrid provide a heterogeneous distributed architecture and are connected by high-bandwidth network links supporting distributed system research. One important feature to note is that some systems can be dynamically provisioned, e.g. these systems can be reconfigured when needed by special software described below, with proper access control by users and administrators.

We had an active year with 105 submitted projects covering our major usage areas: Computer Science and Middleware(59%), Computer Systems Evaluation (29%), Domain Science Applications (26%) and Training Education and Outreach (10%) with some projects having multiple tags and so totals are >100%. Our registered users at end of reporting period was over 1150. In this reporting year, we added significant new support and outreach staff to address identified needs. This cut back our plans to expand hardware resources although we also added the small Bravo and Delta clusters supporting large memory, large disk and GPU applications.

We greatly expanded our support of educational applications as the flexible interactive usage mode of FutureGrid is well suited to education. This was highlighted in an XSEDE all hands meeting AHM paper and BOF. One special highlight was our Science Cloud Summer School with over 170 participants at 10 sites which started July 30 2012. This year also saw an expansion in the use of FutureGrid for testing of XSEDE software both as a test operational Grid and as an interoperability endpoint for SAGA, Genesis and Unicore. International collaborations included the European Middleware Initiative EMI whose software is deployed on FutureGrid with an online tutorial. The cloud projects focused on new experimental applications and new technologies. Here MapReduce is very important as highlighted in substantial interest shown in an XSEDE AHM BOF in this area. FutureGrid offers both Hadoop and Twister as available Platforms as a Service MapReduce systems.

FutureGrid made major progress in the “Cloud Infrastructure as a Service” area with the supported deployment of latest releases of Nimbus, OpenStack and Eucalyptus. We were first academic deployment of the commercial Eucalyptus 3 and this release resolved the major difficulties with the previous release. More importantly we now have a full operational ability called FutureGrid RAIN to dynamically deploy both cloud and bare metal environments on demand and used it operationally for first time at the end of this reporting period. This software is still dependent on some components like the IBM xCAT and Moab that we want to replace (augment) with more general open source systems. Further we are still working on some performance issues. However this demonstrates a new critical feature that “Computing Testbeds as a service” like FutureGrid must address. Our RAIN system integrates an image repository that can store images as templates so they can be deployed on bare metal or different commercial or academic virtual machine management environments. This provides an interoperability capability that will allow applications tested on FutureGrid to be moved to other clouds such as Amazon.

FutureGrid has interacted with XSEDE on integrating accounting approaches, EOT (for example Summer School) and software testing.