

Enabling Access to Grid Computing from Mobile Devices

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I. Research Overview and Outcome

Problem Statement

The latest implementation of the Globus Toolkit provides support for grid computing through web services. The standard implemented by GT4 is called the Web Services Resource Framework (WSRF).

Simultaneously, mobile devices are becoming more ubiquitous but current implementations on these devices do not take advantage of any WSRF-based web services utilized by the Globus Toolkit 4. In Java ME, the JSR-172 API suffers from three key problems:

- No support for Web Services Resource Framework
- No client stub generation with existing WSDL parsers
- Incomplete support for XSD complex data types

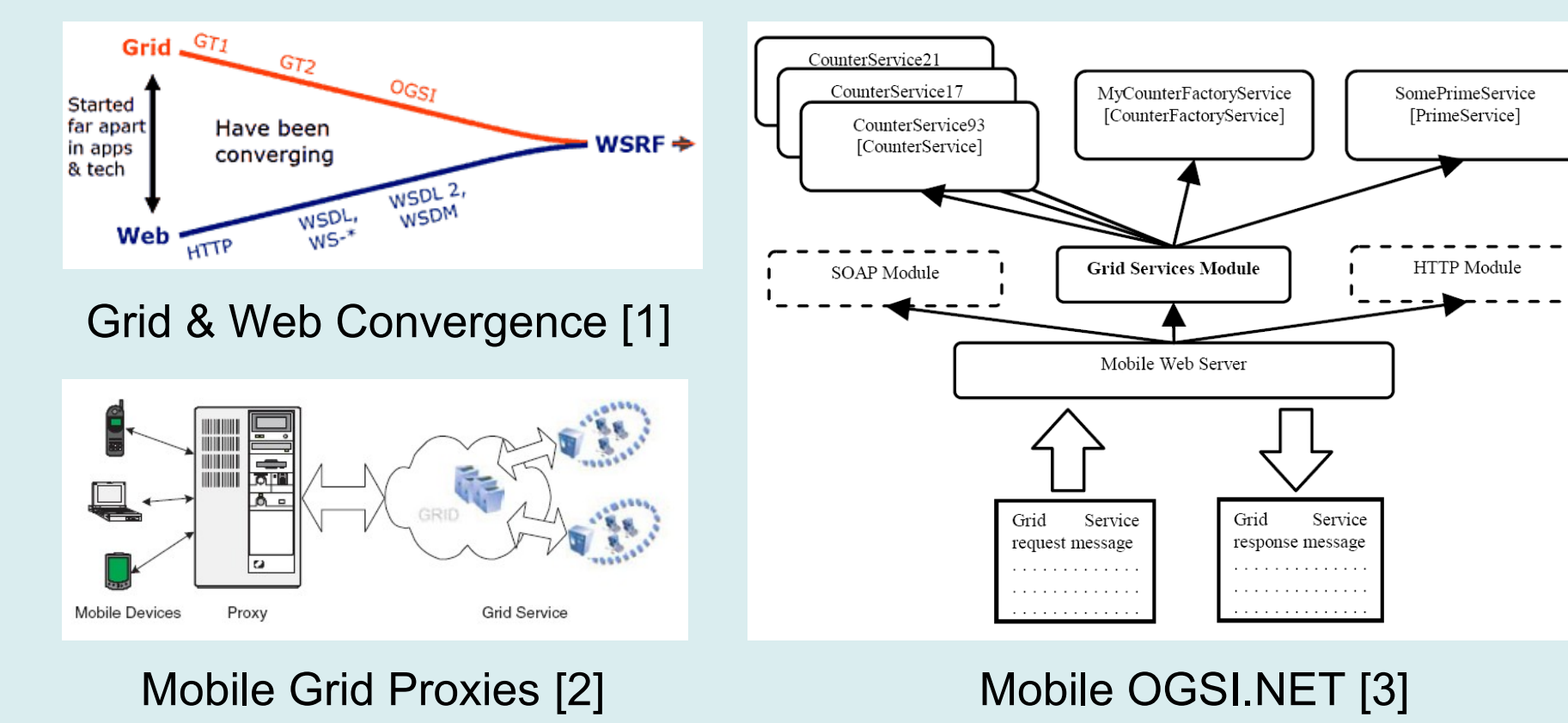
The objective of this research is to create a standardized method for accessing and utilizing grid services based on the Web Services Resource Framework through mobile devices.

Background

The Web Services Resource Framework (WSRF) is based on an earlier implementation called Open Grid Services Infrastructure (OGSI) which aimed to bring web service functionality to grid computing. However, the introduction of new standards such as WSDL 2.0 and WS-Addressing necessitated the creation of WSRF.

Mobile devices are becoming more prevalent in society and continually increasing in computing power and reliability. However, they are one of the computing platforms which are currently underutilized in the domain of grid computing.

Researchers have been investigating methods of incorporating mobile devices into the grid as early as OGSI. Previous work involving bringing mobiles into the grid include Mobile OGSI.NET for the deprecated OGSI.NET implementation and the now-abandoned WSRF4J2ME for the current WSRF standard. Other approaches have involved the utilization of intermediate proxies or managers.

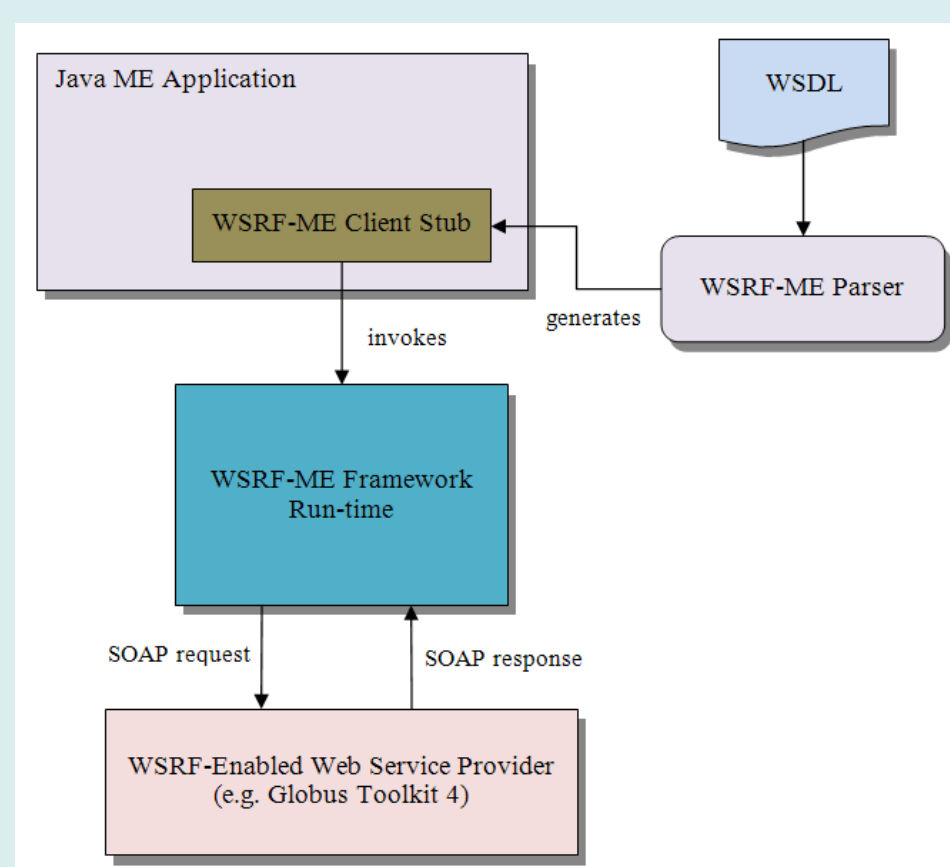


Research Objectives

We proposed the WSRF-ME framework, which is based on the JSR-172 API implementation. Its objective is to enable the use of web services based on the Web Services Resource Framework while adhering to the method in which web services invocations are utilized in JSR-172. The framework consists of a WSDL parser, client side application artifacts, and a framework run-time.

The WSRF-ME framework addresses the three problems defined above by providing inherent support for the WSRF standard, an operational WSDL parser for WSRF-enabled web services, and support custom serialization of complex types.

- WSRF-ME improves on the JSR-172 API by providing support for nearly all of WSRF. It provides full support for WS-Resource, WS-ResourceProperties, WS-ResourceLifetime, as well as partial support for WS-BaseFaults. No support is available yet for WS-Notifications due to a lack of server hosting capabilities on most mobile devices such as cell phones and PDAs.
- The WSDL parser in the WSRF-ME framework allows developers to automatically generate client-side artifacts to invoke WSRF-based web services from a supported mobile device. It also provides support for automatic generation of complex types as defined in a WSDL.
- The run-time portion of the WSRF-ME framework consists of three classes: a manager class and two classes for SOAP encoding and decoding. The SOAP encoder accepts objects that implement the WSRFComplexObject class to enable custom serialization; this allows developers to explicitly define data types as needed when invoking web services.



WSRF-ME Architecture

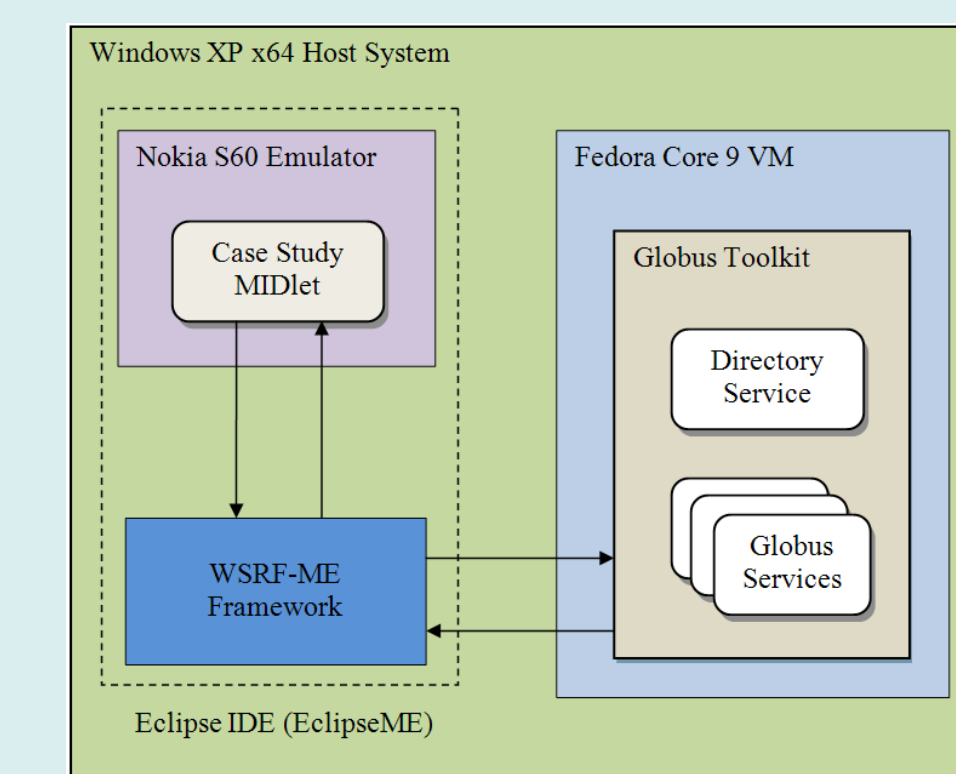
Case Study

The WSRF-ME framework was tested by implementing a case study MIDlet which utilized both a new web service called DirectoryService and standard Globus services including:

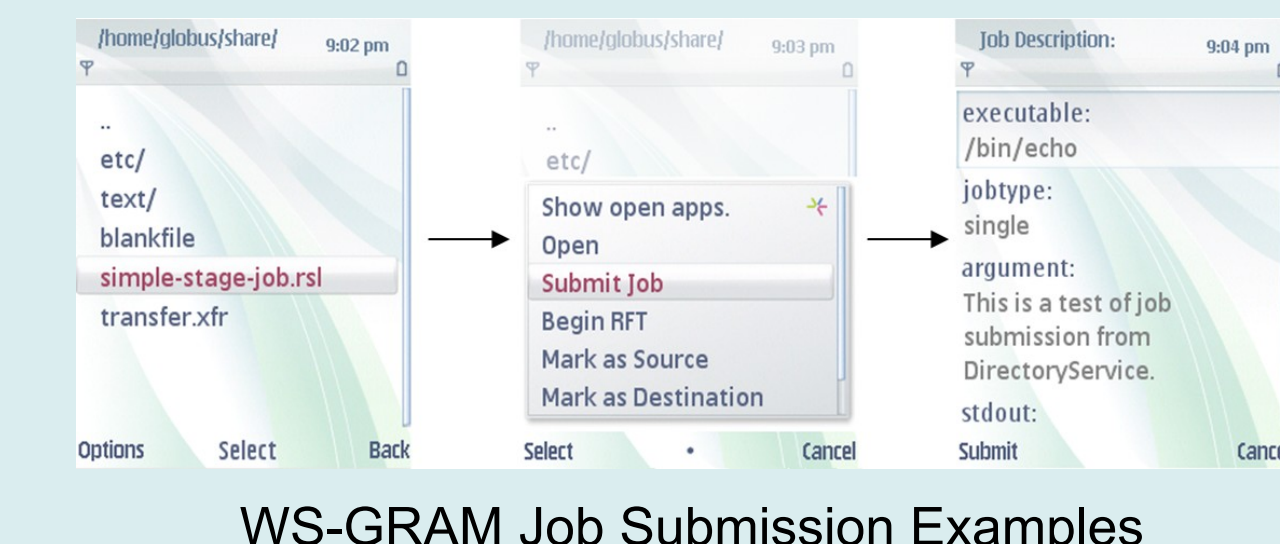
- Grid Resource Allocation Management
- Reliable File Transfers
- Credential Delegation

The server is hosted inside a Fedora Core 9 VM which is running a Globus Toolkit 4.0.7 installation. The application was developed with Nokia's S60 3rd Edition FP2 SDK, Eclipse, and the Eclipse-ME plug-in which integrates the phone SDK.

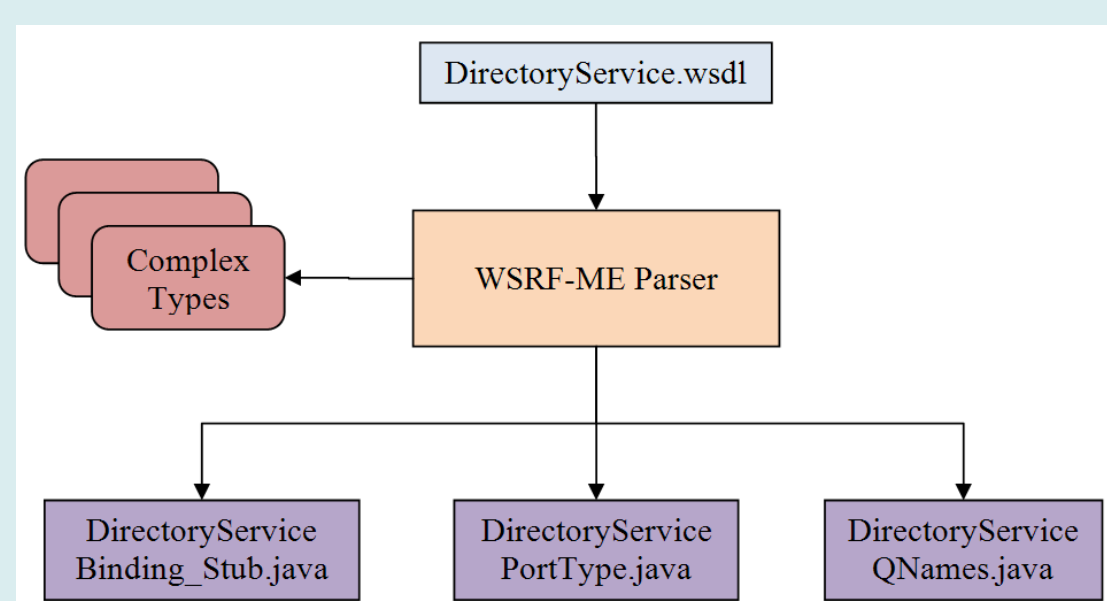
The case study application is a Java ME application streamlined for usability and functionality and allows the user to browse a shared file space, submit jobs to the grid, perform remote file transfers and deletions, and request credentials. The application supports multiple, simultaneous connections to Globus servers and all web service invocations utilized the WSRF-ME framework.



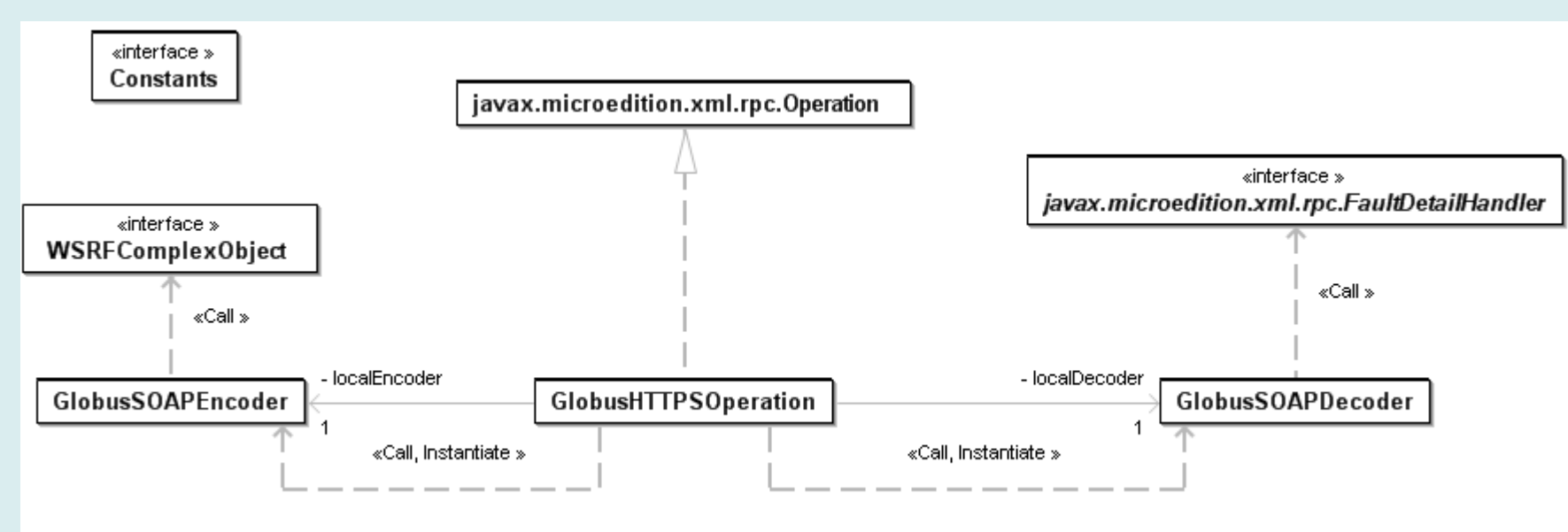
Case Study Simulation Environment



WS-GRAM Job Submission Examples



WSRF-ME Parser



WSRF-ME Framework Run-time

Conclusions & Future Work

The research has resulted in a preliminary yet powerful framework which allows:

- Mobile devices to access WSRF-enabled web services from mobile devices which support Java ME.
- A parser provides support for parsing WSDL files which have WSRF elements in them and generates complex types automatically.
- Custom serialization of complex types is also supported by both automatic means through the parser or through manual creation by developers.

In the future, the framework will be expanded to fully support WS-BaseFaults and further research will be done in possibly creating a method for the mobile device to subscribe to state notifications. Other issues that need to be addressed involve cross-manufacturer interoperability.

II. International Experience

Beijing, China (北京, 中国)

We spent a total of two months living Beijing, China in the Foreigner's Dorms in Tsinghua University. Beijing is one of the Four Great Ancient Capitals of China and is home to Tiananmen Square, the Summer Palace, the Temple of Heaven, and many other cultural landmarks.

During our two month stay we got the opportunity to experience first hand both the Chinese culture and its excellent food; everything from Beijing roast duck (北京烤鸭) to Tsingtao beer (青岛啤酒) – thanks to the excellent conversion rate on the Chinese RMB and the low cost of food in China we ate very, very well.

As for the language, foreigners have a hard time learning Chinese because of its four tones and complex calligraphy. We did learn the basics during our stay including phrases such as "Hello" (你好), "Good-bye" (再见), "Thank-you" (谢谢), "Beer" (啤酒), and others.

We also had the support of the students from Tsinghua who were instrumental in helping us survive the first few weeks when we were completely unable to communicate with most people, let alone read anything.



Tiananmen Square

Great Wall (长城)

We also got the opportunity to climb and camp on the Great Wall in a rural area two hours outside of Beijing. It was amazing to see the rural country side of China which is so different from the urban areas in Beijing.



So much food...

We also had the chance to taste some authentic Chinese food which was made by the owners of a farm at which we stopped. It was delicious and I think we had trouble eating it all. It was also amazing to see the Great Wall in an area which not too many tourists visit.



The Great Wall

The trip was an amazing experience and I'm grateful for Chris for finding out about this opportunity. It was really amazing to see this unique part of the Chinese cultural legacy.

Tsinghua University (清华大学)

Tsinghua University is the number one university for Computer Science majors in China and is one of the best universities in the country. I worked with Dr. Junwei Cao and his students.

The university is simply amazing, the size difference compared to Florida Atlantic University is immense. Fortunately, our hosts at Tsinghua were gracious enough to help us find bicycles to ride. We managed to learn to use our bicycles as much as possible and as the picture below shows, so do all the local students! In cases where it wasn't feasible to bike to our destination we also had access to taxis, subways, and the buses.

The lab students also work very hard and I think I learned a great deal about how to approach my problems in new ways during my stay there. Dr. Cao's students were always available to help and I'm grateful for their hospitality. Their expertise with the Globus Toolkit helped me understand some concepts I wasn't familiar with and helped me develop my framework. It helped me learn a great deal about grid computing and built the basis for the WSRF-ME framework.



Tsinghua Campus

Summer Palace (颐和园)

The Summer Palace was an interesting experience even with all the immense amounts of walking we had to do. The entire place is enormous and we probably only managed to visit about half of it the entire time were there. There was a lot of interesting things such as a Buddhist Temple and the Marble Boat. I took some pretty nice pictures there, one of which is shown to the right.



Bridge next to the Long Corridor

Other areas which were interesting included the Long Corridor which is over 728m long and had tons of traditional Chinese paintings. Next time I visit China I hope I can visit the other parts of the Summer Palace I didn't see.

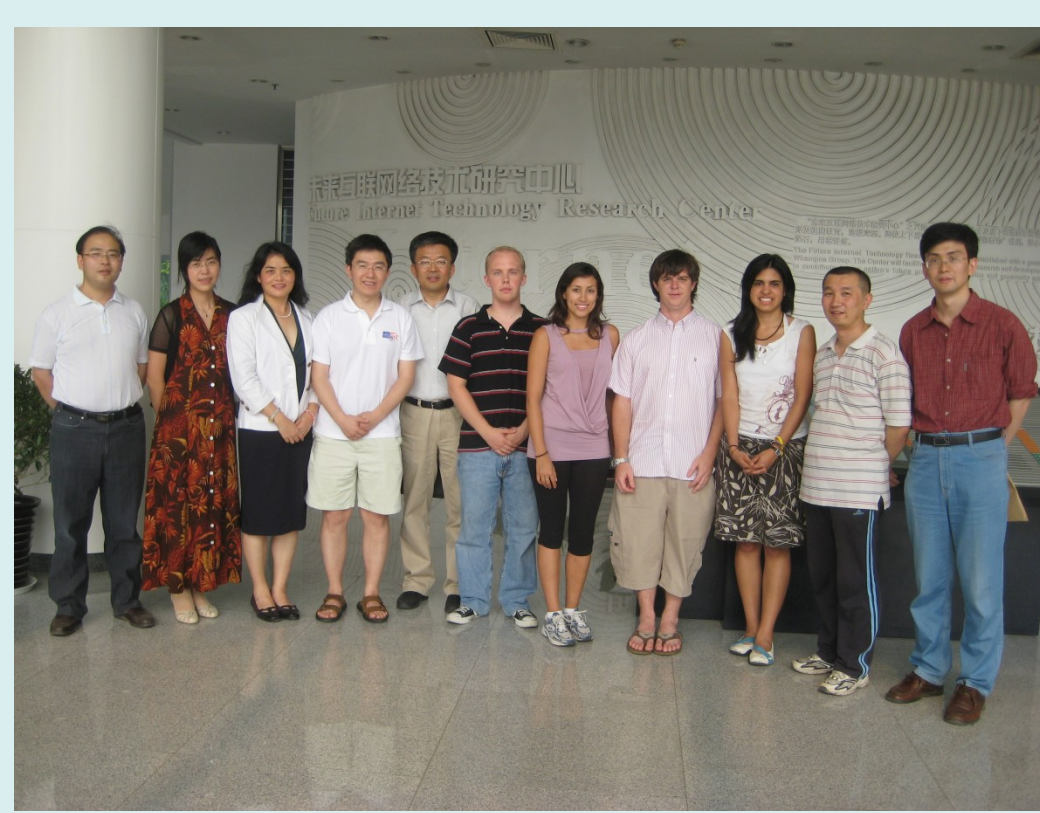
Temple of Heaven (天坛)

The Temple of Heaven is a very old complex which was used by Chinese emperors to pray for a good harvest. The building in the picture on the right is the place which the Emperor would normally divine fortunes about that season's harvest.

The Temple of Heaven complex is huge and has lots of older Chinese people playing Xiangqi (象棋) which is a more complex version of Western chess. We also got to see other parts of the Temple of Heaven such as the Wall of Reflection where people's voices could be reflected due to special geometrical shape of the architecture and its surrounding wall.



No one goes without a bicycle



PIRE China at Tsinghua



Tsinghua's Old Gate

III. Acknowledgement

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