

***KFUPM - COMPUTER ENGINEERING DEPARTMENT*****COE-540/ICS 570 – Computer Networks****Projects Statements**

---

The following are the suggested project topics for students registered for COE 540 and ICS 540.

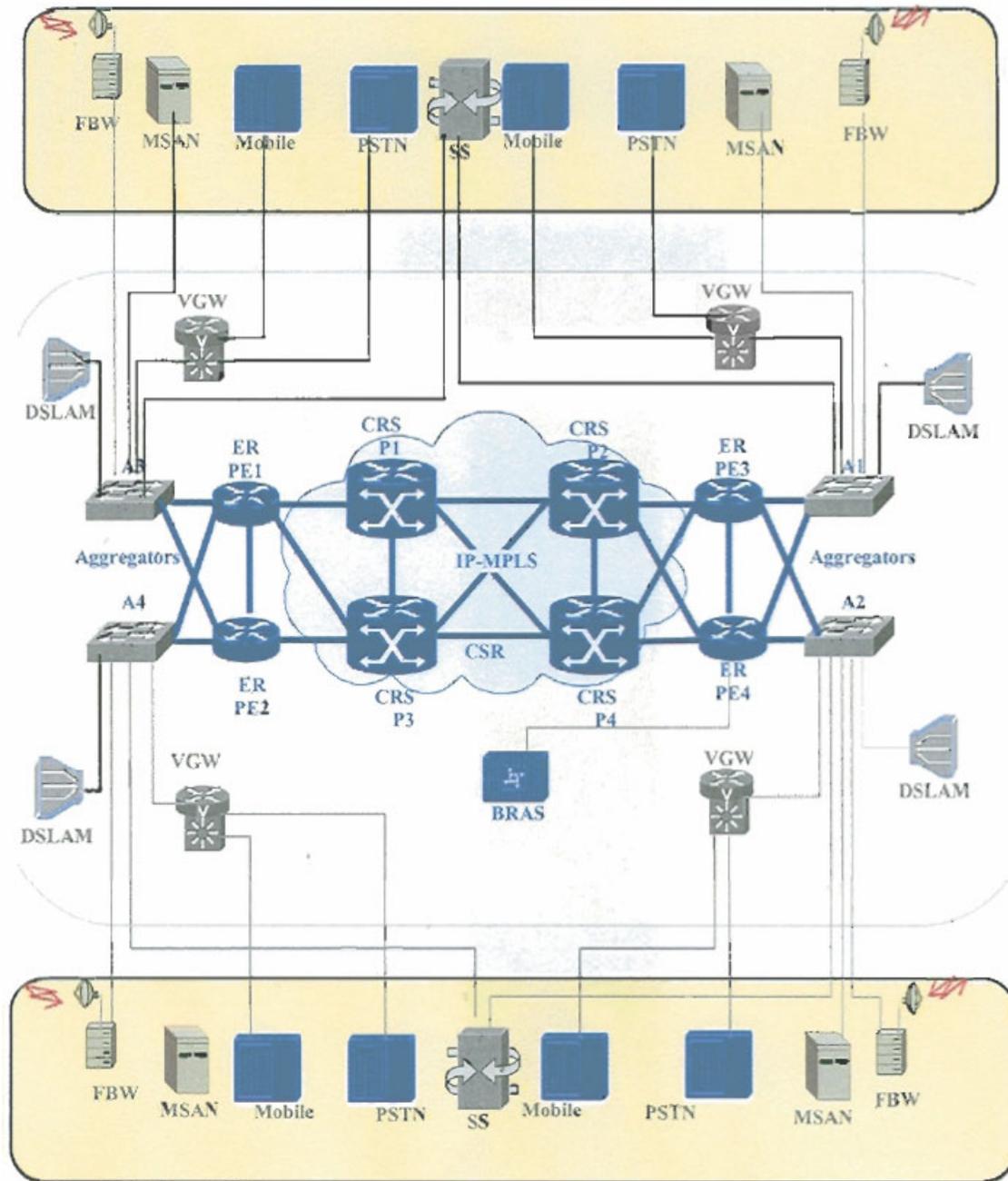
**Project #1: Performance Evaluation and Optimization for Service Provider Core Network****Project Statement:**

Fig. 1 depicts an example of a core network configuration for a service provider. The configuration consists of the following equipments:

- Four (4) Cisco CRS core routers
- Four (4) Cisco 7613 edge routers (ERs)
- Four (4) Cisco 7609 Aggregator Switches (A1, A2, A3, and A4)
- One (1) Juniper ERX BRAS
- Two (2) Alcatel IP-DSLAM

Please note the all entities except for the core routers, edge routers, and switches are actually traffic sources as far as the core is concerned. For example, the fixed broadband wireless (FBW) traffic is routed to the core through the aggregator switches. The same is true for the Mobile network traffic, the public switched telephony network (PSTN), and other networks depicted in the diagram.

It is required to model and characterize the network shown in Fig. 1 using OPNET. In addition to the modeling and characterization, it is also required to identify any bottlenecks in the shown configuration and propose alternative designs. The use of OPNET is a must in this project.



**Fig 1: Service provide core network configuration.**

The following is a tentative table prepared by Mohammed Aabed in regard to the network entities identified in Fig. 1 and their substitute in OPNET. Please note that this mapping is not complete and may have been updated since the mapping was created last year! The instructor will provide more details in regard to the network entities and the link types as the project progresses and as information become available. For the time being, the students are asked to make their own (reasonable) assumptions in regard to the connectivity in Fig. 1. In addition and as a start not all the traffic sources are required. Initially, restrict your model to FBW, PSTN, Mobile, and DSLAM.

**Table 1: Tentative mapping table between actual network entities and equivalent OPNET entities.**

Devices (as per Fig. 1 requirements)	OPNET Available Substitute Models	Notes	
CISCO CRS	CS_12008_8s_a5_fe8_ge1_sl9 CS_12012_12s_a10_fe8_ge1_sl17 CS_12016_16s_a10_fe8_ge3_sl24 CS_12410_5s_a4_ge8_fr6_sl8_srp	Exact device not available. CISCO website classifies both 12000 Series and CRS as devices for Core Networks for Wireline Carriers.	
CISCO 7613	CISCO 7609	Both belong to the same family (7600 series) with minor differences between the two models	
CISCO 7609	CISCO 7609	Described as an "edge router that delivers robust, high performance IP/MPLS features for a range of service provider edge and enterprise MAN/WAN applications" as per manufacturer's website.	
Juniper ERX BRAS	JN_ERX705_7s_a4_fe8_fr16_sl8 JN_ERX1410_14s_a4_ge2_fr8_sl8	All service as ERX BRAS according to the manufacture's website	
Alcatel IP-DSLAM	DSLAM_atm1_ip32 DSLAM_atm8_ip8 DSLAM_fr1_ip32	Exact device not available. All the listed are generic models.	
VGW (Voice Gateway)		No specific Voice Gateway is available in OPNET. Perhaps any GW can be used	Lots of details may have to be verified for these parts to be modeled exactly. There are many varieties of topologies and configurations.
FBW (Fixed Broadband Wireless)			
MSAN (Multi-Service Access Node)			
Mobile			
PSTN		Many Models available	
SS (Signaling System)			

## **Preliminary Approach/Steps**

As the corresponding network diagram is missing some information at this moment, the steps below are the preliminary required steps. More steps and details will be added as the project progresses.

1. Study the network diagram in Fig. 1 THOROUGHLY and identify the function and configuration of the depicted network entities.
2. Build your own mapping table (similar to Table 1) where you specify the actual network entity and the corresponding OPNET model.
3. Build an OPNET project that corresponds to the network shown in Fig 1. You will have to restrict your model to a subset of the traffic sources. You need to make reasonable assumptions about the connecting links.
4. Make sure the four core routers form an IP-MPLS network.
5. Assume input traffic patterns (defined as background traffic or network flows) in the considered traffic sources. For more information regarding background traffic and network flows please refer to the online tutorials and the example projects within OPNET.
6. Select representative performance figures to monitor (link/port throughput, delay, etc.) and collect required statistics.
7. Experiment with different routing policies and traffic loads. Document your results and make your conclusions.
8. Prioritize traffic to give PSTN traffic and Mobile traffic higher priority relative to FBW and DSLAM for example; Enforce this priority scheme on IP-MPLS network – obtain results and compare to the no-priority case.

## **Deliverables**

1. A monthly report describing progress, developed models, and obtained results for each of the simulation scenarios considered.
2. A final report that includes all simulation scenarios, optimizations, and results.
3. A final presentation (powerpoint) document summarizing the project and its findings.
4. All previous material should be put on a CD. The CD should contain the following folders:
  - a. Documents folder – containing all reports, needed documents, and presentation.
  - b. References folder – containing all needed references and webpage articles needed and used in this work.
  - c. Code folder – containing all required OPNET (or otherwise) code in electronic and operational form. If the work involves more than one running code (say

one per simulation scenario), then include one Code folder for each running code.

- d. Figures folder – containing subfolders with one subfolder per figure in the paper. The subfolder contains the code used to generate the data or spreadsheet data as well as the raw figure.

## **Project #2: Broadband Access Characterization for Residential Customers Using ADSL and Indoor WiMAX**

### **Project Statement**

ADSL technology provides broadband data service for residential customers and small businesses. The quality of the provided service is a sensitive function of the distance between the outlet and the distribution point in the neighborhood. Typical distances range from 100s of meters to may be 1 or 2 km. For distances beyond the design limit, the frame error rate (FER) may be unacceptable and some ADSL modems may not support such links (i.e. the modem is strict and requires a certain FER to operate). In some scenarios, it may be acceptable to both the customer and service provider to extend the range of the link in terms of distance at the cost of less-than-standard service quality. Some customers who are living away from the distribution points may accept service that would otherwise be considered not acceptable for standard ADSL service. This alternative allows the service provider to extend the ADSL service without the installation of new distribution points in the residential area of interest. It is required to evaluate the performance of typical internet applications as a function of extended link range for ADSL. In addition, it is required to evaluate the suitability of indoor WiMAX as an alternative solution for broadband access for residential and small business areas.

### **Preliminary Approach/Steps**

1. Evaluation of standard ADSL service quality
  - a. Build a small project in OPNET where two nodes A and B are connected using an ADSL connection. Node A is the client running a mix of internet applications (HTTP, Email, FTP, etc.) while node B is the ISP service providing services to the assumed internet applications.
  - b. Define the application usage or mix in OPNET. For this you will need user profile configuration and application configuration nodes.
  - c. Assuming optimal link length (or quality), evaluate the internet application performance
  - d. Search the literature and define a relation between bit error rate (BER) or frame error rate (FER) and the link distance for a given copper quality.
  - e. Now for all distances of interest, lookup the BER value from the curve defined in (1.d), plug into the ADSL link attributes and rerun the simulation to evaluate the internet applications performance in terms of delay and throughput.

- f. Plot curves of delay and throughput versus distance. The point obtained in (1.c) is our reference point, while the rest of points obtained in (1.e) represent non-standard operation points.

## 2. Wireless Indoor WiMAX Evaluation

- a. Use the internet to survey products and services utilizing wireless indoor WiMAX where the customer purchases a WiMAX CPE and deploy it WITHOUT the need for the service provider to send a technician or an engineer to align the unit. An example of such products can be found at: <http://www.wimax-industry.com/ar/8t.htm> – quoting from the webpage: “Redline’s RedMAX SU-I is a user-install, “plug and play” indoor WiMAX modem that delivers personal broadband connectivity to residences and small to mid-sized enterprises. The SU-I will allow service providers and operators to deliver services quickly, easily add new customers and realize a return on their WiMAX infrastructure investment. Operating in the 3.3 – 3.5 GHz licensed frequency band and designed to WiMAX Forum Certified™ specifications, the RedMAX SU-I incorporates an attractive and innovative design with the smallest form factor in the WiMAX industry.”
- b. Summarize the products obtained in (2.a) in a table comparing the relative ease of deployment, operating frequencies, supported range of distances, supported bits rates, etc. We would like also to know the power budget parameters for the supported uplink and downlink using this technology. Those are best obtained from the specification sheets from such products or from conference papers in the field. Link power budget parameters include basestation transmit power, acceptable SNR (or Eb/No) for correct reception, maximum affordable path loss in dBs, etc.
- c. Obtain typical RF propagation characteristics for a typical urban city in KSA such as Riyadh or Dammam. The characteristics include average signal attenuation due to building materials, building heights, number of floors, street orientations. The purpose of this step is to be able to calculate the average SNR received indoors by the CPE from a cell site placed in the city and also the average SNR received by the cell site from the CPE transmitted signal. The outcome of this step is an RF model customized to reflect the typical urban city in KSA.
- d. Use the RF model developed (or assumed) in (2.c) to calculate the average SNR at various ranges and the corresponding BER. Map the obtained BER or FER to the throughput and delay curves obtained in (1.f).

## Deliverables

1. A detailed interim report specifying the ADSL performance in terms of delay and throughput for the assumed internet applications, as a function of the link range. This report should also specify the simulation specifics and your assumptions. This interim report should be finalized in about 30 days from the start of the work to allow for corrections and comments from instructor.
2. A detailed interim report containing the survey for indoor WiMAX services and their characteristics. The report should also contain all information found in regard to RF propagation within cities in KSA. Finally, the report should contain your final performance curves using the WiMAX link as opposed to the ADSL link. This

interim report should be finalized in about 30 days from the end of steps 1.a, 1.b, 1.c, 1.d, 1.e, and 1.f to allow for corrections and comments from instructor.

3. A final report combining the interim reports in (1) and (2) with focus on presentation of comparison between the two technologies in terms of performance and coverage.
4. A final presentation (powerpoint) document summarizing the project and its findings.
5. All previous material should be put on a CD. The CD should contain the following folders:
  - a. Documents folder – containing items 1, 2, 3, and 4.
  - b. References folder – containing all needed references and webpage articles needed and used in this work.
  - c. Code folder – containing all required OPNET (or otherwise) code in electronic and operational form. If the work involves more than one running code, then include one Code folder for each running code.
  - d. Figures folder – containing subfolders with one subfolder per figure in the paper. The subfolder contains the code used to generate the data or spreadsheet data as well as the raw figure.

### **Project #3: WLAN/3G Integration Architecture and Performance Characterization**

#### **Project Statement**

The following paper

N. Banerjee, W. Wu, K. Basu, S. Das, "Analysis of SIP-based mobility management in 4G wireless networks," Elsevier Computer Communications 27 (2004) 697-707

is an example of an analytical study evaluation the performance of an integrated WLAN/3G network. The paper assumes a SIP-based mobility solution. Core model used in the paper is shown in Fig. 8 where multiple M/M/1 queues and a single M/G/1 queue are assumed to represent the processing required to carry out the transactions shown in Fig. 4, Fig. 5, Fig. 6, and Fig. 7. The queues are arranged in a simple single path feedforward network. It is required to reproduce the paper results assuming the following mobility solutions: Mobile Stream Control Transmission Protocol (mSCTP) and Mobile-IP.

#### **Preliminary Approach/Steps**

The basic formulas for M/M/1 and M/G/1 queues will be covered in class as part of the queueing theory material required for COE 540 and ICS 570. While the formulas are simplistic they provide a mean to estimate the mean waiting delay. The key approach to the above problem is to identify the required transactions required for the network to operate using the specified mobility solutions. For this part, the student may find the following

resources very useful. These resources contain explicit diagrams for the required signaling and transactions to implement the specified mobility solutions. The resources are:

- [1] Ejaz Rahman, Junaid Jaffar, "Investigation of WLAN-Cellular Integration Architecture for Cellular Operators and Deployment Issues at King Fahd International Airport," Senior Design Project Report, Computer Engineering Department, KFUPM, Jan 2006.
- [2] Ismat Maarouf, Mohammed Aabed, "A Comparative Analysis of Different Integration Approaches Between UMTS and WLAN Networks," COE 587 course project paper, Computer Engineering, KFUPM, May 2006.
- [3] Sayed Asadullah, Ashraf S. Mahmoud, Marwan Abu-Amara, Tarek Sheltami, "Vertical Handoff Characterization for SIP and mSCTP Based UMTS-WLAN Integration Solutions," to appear in proceedings of 4<sup>th</sup> GCC-IEEE Conference, Manama, Bahrain, Nov 2007.

For example in resource [1], you need to focus on the evaluation of the message exchanges depicted in Fig. 37 and Fig. 38 for Mobile IP, Fig. 40 and Fig. 41 for SIP, and Fig. 43 and Fig. 44 for m-SCTP. The situation is similar for the other two resources and the references within. Please note that the shown transactions may be approximate, for more detailed info about the transactions and the involved number of bytes it is recommended to visit the quotes references within the resources. The recommended steps are as follows:

1. Read the Banerjee's Computer Communications paper and reproduce all the curves. This will ensure you have captured all the required information and assumptions.
2. Use the above resources and the references therein to identify the messages exchanged and their volume using the two specified mobility solutions: m-SCTP and Mobile IP. Make the needed reasonable assumptions to fill in the missing information in regard to transmission rates, processing speeds, etc.
3. Develop an equivalent queueing model similar to that in Banerjee's paper Fig. 8.
4. Apply the same analysis in Banerjee's paper and reproduce the figures but using the new calculated mean service time for the new queues.
5. Put all your results and finding in writing in a paper form – The final paper should be written to the parallel for o the original Banerjee's paper.

## **Deliverables**

The team is expect to make the following deliverables

1. A document specifying all transactions and message exchanges required to implement the mobility solutions: SIP, m-SCTP, and Mobile IP. The document should draw the equivalent queueing model for each of these mobility solutions.
2. A well-written paper that is parallel to that of Banerjee's. The paper should also contain a comparative analysis of results to compare SIP, Mobile IP, m-SCTP.
3. A power point presentation describing the study and its findings.
4. All previous material should be put on a CD. The CD should contain the following folders:

- a. Documents folder – containing items 1 and 2.
- b. References folder – containing all references in electronic form
- c. Figures folder – containing subfolders with one subfolder per figure in the paper. The subfolder contains the code used to generate the data or spreadsheet data as well as the raw figure.

## **General Rules**

**Project Selection:** Student will form teams of three students per team. A team of one student or two students should be an exception. Teams send their project selection preference to the instructor in the form of: project A, project B, and project C, where A is the highest preference and C is the lowest. Choices will be granted on a first-come first-served basis with an attempt to balance the choices such that almost a third of the class is working on any one project.

**Help with OPNET:** OPNET is a powerful and very vast simulation tool. It requires a reasonable learning curve. Online help material and tutorials exist. There exist specific material in regard to the following subjects in OPNET:

- Building user/application profiles.
- ADSL links
- MPLS network setup

If any of the above material is required please arrange to see the instructor. The material is proprietary and can not be released in softcopy for the public.

**Project Progress:** Start early and account for surprises. Handling software packages and dealing with CCSE network requires that you budget a safety time margin for your deliverables. You can not assume that all needed resources will exist and be operational at the first time you need them (network shutdowns for example).

**Proprietary Projects:** The projects specified in this document and the description included are the result of the effort of the instructor. These projects are derived from projects that are in the “active state” with the industry. Therefore, students are encouraged not to share specific project details with outside parties.

**Master Thesis Subjects:** For projects (1) and (2), the instructor will evaluate the submissions thoroughly and will consider extending these topics for Masters Theses for students with best performance in the project area. If the instructor and a student agree to pursue a Masters Thesis in projects (1) or (2), funding for the student may be provided from the project budget.

## **Timeline and Deadlines**

In addition to the deliverables specified in sections above, all teams are required to submit the following:

End of September	Team members and project selection
End of October	1 <sup>st</sup> progress report
End of November	2 <sup>nd</sup> progress report

Dr. Ashraf S. Hasan Mahmoud

9/25/2007

December 30<sup>th</sup>

Final report and powerpoint presentation

January 15<sup>th</sup>

The CD containing all required material.

Please remember that ALL presentations should be available and distributed to all class students on WebCT prior to the presentation weeks (week of Jan 5<sup>th</sup> and Jan 12<sup>th</sup>) so that students can evaluate each others presentations.

Abiding by the announced timeline is a must for all students.