Enhancing the GPRS Environment with Differentiated Services and Applying Congestion Pricing

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Thesis Outline

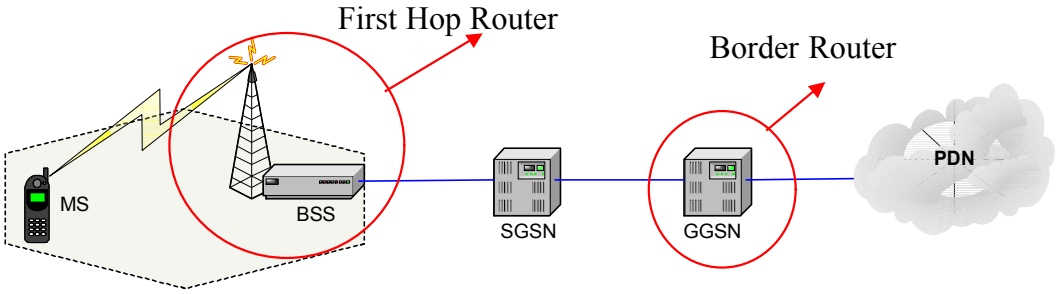
- Apply real QoS techniques in the GPRS environment
  - End-to-end QoS
  - Emphasis on the radio link ⇒ congestion point
  - Use the existing resource allocation techniques of GRPS specs
  - Compatibility with existing Internet solutions

Þ Two-bit Differentiated Services

- Charge the use of priority/service classes
  - More efficient resource allocation
  - According to the congestion level of each class
  - Maximize the benefit for the user and the network operator

Þ Congestion Pricing

DiffServ Architecture into GPRS

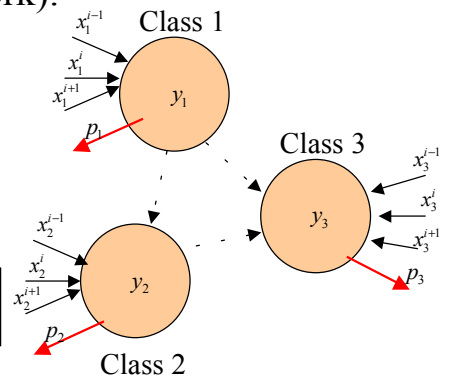


- Two-Bit Differentiated Services Architecture
- Distributed traffic conditioner (MS and BSS)
- BSS: simulation of first hop router's functions (software upgrade)
- Simplicity and speed
- Use of USF, Countdown Value (CV) and the existing procedures of PDP Context activation and TBF establishment

Charging use of DiffServ classes (1)

- Class 1: highest priority
  Class 3: lowest priority
- Maximization of Social Welfare (Network):

$$\max_{\{x_1^i, x_2^i, x_3^i \geq 0\}} \sum_{i=1}^{n} V_i(x_1^i, x_2^i, x_3^i)$$



- Maximization of net benefit (User):

$$\max_{\{x_1^i, x_2^i, x_3^i \geq 0\}} \left[V_i(x_1^i, x_2^i, x_3^i) - p_1 x_1^i - p_2 x_2^i - p_3 x_3^i \right]$$

- Utility gained from use of classes:

$$V_i(x_1^i, x_2^i, x_3^i) = u_i(x_1^i, x_2^i, x_3^i) - g_1^i d_1(y_1) x_1^i - g_2^i d_2(y_1, y_2) x_2^i - g_3^i d_3(y_1, y_2, y_3) x_3^i$$

Charging use of DiffServ classes (2)

- In the optimal point, the unit prices for each class are:

$$p_1 = \frac{\partial d_1(y_1)}{\partial y_1}\sum_{i=1}^{n} g_1^i x_1^i\Big|_{x=x_1^*} + \frac{\partial d_2(y_1,y_2)}{\partial y_1}\sum_{i=1}^{n} g_2^i x_2^i\Big|_{x=x_2^*} + \frac{\partial d_3(y_1,y_2,y_3)}{\partial y_1}\sum_{i=1}^{n} g_3^i x_3^i\Big|_{x=x_3^*}$$

$$p_2 = \frac{\partial d_2(y_1,y_2)}{\partial y_2}\sum_{i=1}^{n} g_2^i x_2^i\Big|_{x=x_2^*} + \frac{\partial d_3(y_1,y_2,y_3)}{\partial y_2}\sum_{i=1}^{n} g_3^i x_3^i\Big|_{x=x_3^*}$$

$$p_3 = \frac{\partial d_3(y_1,y_2,y_3)}{\partial y_3}\sum_{i=1}^{n} g_3^i x_3^i\Big|_{x=x_3^*}$$

that is to say, equal to the extra (marginal) delay cost suffered by all the users of the specific class and the lower ones due to the marginal increase in demand for the services provided by the specific class

- Use of tatonnement for price determination: $p_i^{t+1} = a\,\hat{p}_i^t + (1-a)p_i^t$