AN ASYMMETRICAL POLLING SYSTEM WITH
GENERAL SERVICE ORDER SEQUENCE AND
GATED-LIMITED SERVICE DISCIPLINE

Chung-Ju Chang and Lain-Chyr Hwang
Department of Communication Engineering
National Chiao Tung University
Hsinchu, Taiwan 30039
Republic of China

Abstract: An asymmetrical polling system which has various traffic load or different service requirement for each station is analyzed. We assume the arrival processes for stations to be Poissonbously distributed with different rates, and the service times and waiting times to be generally distributed with different means. Each station of the polling system is attended according to a general service order sequence and is served with gated-limited service discipline. The analysis approach is by way of an imbedded Markov chain method. The obtained results are mean waiting times of stage and station, respectively.

INTRODUCTION
Polling schemes have a wide range of applications in the field of local area networks such as token-bus network, token-ring network, and distributed process systems such as telephone switching system, computer system, and control system. There are many sorts of polling schemes if the service order sequence and the service discipline are different. Normally, the service order sequences have cyclic service order and general service order [1], and the service disciplines are (i) exhaustive, (ii) gated, and (iii) limited [4-6]. For limited type, there are three sub-types: (i) nonexhaustive, (ii) gated-limited (or G-limited), and (iii) exhaustive limited (or E-limited) [5-7].

Many papers studied about polling systems with various service disciplines [1-10]. But, the analysis of the polling system with limited service discipline and/or with general service order is few. However, an integrated services network providing multimedia services, for example, has heterogeneous customers of which the delay requirements are different for each station; or a switching system or a local area network has different traffic loads for each station. For such an asymmetrical system, if polling scheme is adopted, the general service order sequence will make the system load more balanced (fair) or the delay requirements more satisfactory. Thus a G-limited polling system with general service order sequence is an interesting problem to be studied.

ANALYSIS
We use stage to express the turn in the polling sequence. Let r and i denote the indexes of station and stage, respectively. and r_i denote the number of customers at stage i. We set four observation points at the epochs of server's arrival at and departure from a stage, and beginning and ending of a customer, respectively. A epoch of customer's service begins is also a epoch of server's arrival or a epoch of customer's service beginning. Similarly, a epoch of customer's service ending is also a epoch of server's departure or a epoch of customer's service.

Thus we have
\[ \beta_i b_i(z) + d_i(z) = \beta_{i-1} e_{i-1}(z) + a_i(z), \]

where the \( b_i(z) \), \( d_i(z) \), \( e_i(z) \), and \( a_i(z) \) denote the probability generating functions of \( b_i(n) \), \( d_i(n) \), \( e_i(n) \), and \( a_i(n) \), respectively. The \( b_i(n) \) and \( e_i(n) \) are the probability that there are \( n \) customers in station \( r_i \) when a customer begins and ends service at stage \( i \), respectively; the \( d_i(n) \) and \( a_i(n) \) are the probability that there are \( n \) customers in station \( r_i \) when the server departs from and arrives at stage \( i \), respectively. The \( \beta_i \) is the mean number of customer's service—beginning (or service—ending) per server's arrival at stage \( i \). Via a more intuitive approach, we derive the formulae of the mean waiting times of stage \( i \), \( w_i \), and station \( r \), \( v_i \), respectively.

These two formula are given below:

For nonexhaustive type,
\[ w_i = \frac{v_i}{(1 - \rho_i)} \]

and
\[ v_i = 2(1 - \rho_i) \]

where \( \lambda_i \) and \( \rho_i \) are the arrival rate and the traffic intensity for station \( r_i \), respectively; \( c \) is the mean whole cycle time; and \( s_i \) and \( s_i^{(2)} \) are the first and the second moments of the service time for customers in station \( r_i \), respectively.

CONCLUSIONS
We find some characteristics from numerical examples. The mean waiting time increases with the increases of arrival rate, mean service time, and mean walking time. We also find that, as the traffic intensity increases, to decrease the service rate would make the mean waiting time more deteriorate than to increase the arrival rate. The waiting time of the multiple-poll station will get much gain that its mean waiting time can be made smaller. But, when the traffic intensity gets larger, the profit will decay such that its mean waiting will become the largest.

REFERENCES