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TO POOL OR NOT TO POOL? "THE BENEFITS OF COMBINING QUEUING AND SIMULATION"

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ABSTRACT

"Should we pool separate queues into a single queue or not?" A question as practical as for daily-life situations such as at a bank, a hospital or a service center as well as for technical applications such as in manufacturing or call centers. A question that involves fundamental insights of queuing theory. A question that can only be answered in a realistic situation by simulation. A question that is still open for practical and fundamental research. A question that requires a hybrid combination of queuing and simulation. A question that in realistic situations not only benefits from but even requires a hybrid combination of analysis and simulation. This paper aims to illustrate that simulation and queuing theory can and should go hand in hand for a variety of practical problems, both in daily-life and industry. To this end, it will highlight real-life cases taken from daily-life situations (postal office or bank), administrative logistics (reengineering), transportation (railways) and call center analysis.

1 BACKGROUND

Delays and queuing problems are most common features not only in daily-life situations such as at a bank or postal office, at a ticketing office, in public transportation or in a traffic jam but also in more technical environments such as in manufacturing, computer networking and telecommunications. And most actually, they appear to play a crucial role for business process reengineering purposes in administrative logistics.

2 QUEUING

Ever since the origin of classical teletraffic (telephony) theory in the twenties, queuing theory has been highly developed and extensively applied in telecommunications. At later instance, in the seventies, its application has been extended to computer performance evaluation and manufacturing.

Generally, however, the application of queuing theory for daily-life problems has remained rather restricted. The perception seems to have grown that queuing analysis is too detailed and too mathematically complex to allow for a direct practical application, other than for technical or industrial purposes. This perception seems to be strengthened by queuing theoreticians and their publications that mainly highlight the mathematical and technical issues rather than general insights. At the same time questions as simple and practical as should we pool or not still appear to be open from a queuing point of view.

3 SIMULATION

Just oppositely, simulation has proven to be a most powerful tool to model and evaluate such realistic situations both in daily-life and industrial environments. Accordingly, it has become a most valuable tool for evaluating purposes of existing situations. However, for optimization or design purposes, *simulation* might easily become too costly or impractical as no general directions are available for setting up variants to compare, even not for questions as simple as *should we pool or not.*

4 HYBRID COMBINATION

As a step to narrow this discrepancy, this paper aims to illustrate and promote that a hybrid approach of queuing and simulation can be most fruitful: By *queuing* general rules and insights might be suggested to direct the way of thinking and to suggest a number of operational variants. By *simulation*, in turn, these general insights can be compared and made practical by evaluating and comparing a limited number of variants. The general advantage and disadvantages of both are listed in table 1.

Table 1: Comparison of Queuing and Simulation

Queuing	Simulation
Advantages	*Disadvantages*
Insights 100% exact Generic components No detailed data necessary	Numbers Confidence? Too much complexity Detailed data required
Disadvantages	*Advantages*
Too restricted for reallife modelling Strongly simplified uncertainty-assumptions (exponentiality)	Allows real-life complexity Allows real-life uncertainties

By combining both approaches the advantages of both are exploited.

To this end, this paper aims to show that a hybrid queuing and simulation approach can be most beneficial and should generally be strived for in practice. To this end, five real-life applications will briefly be discussed.

4.1 Application 1: Pooling (Case 1)

"Should we pool capacity or not" is a question of general interest, at the level of a postal or bank office, of parallel machines, up to even the level of departments that may have to be combined. Generally, *pooling* is considered to be superior as capacity of resources then seem to be used more *efficiently*. However, one aspect is then not taken into account: *the aspect of variation.* By queuing theory this aspect is known to be the most important factor for waiting situations to arise in the first place.

4.1.1 Case 1: The Dutch Postal Offices

Based on general queuing theory results, a study has been set up for the Dutch Postal Offices, fig.1, in order to investigate the possible improvement of the current single-line operation. Next to general results and insights, results for specific pilot-offices were obtained. Below the results for the Pilot-Office of Schiedam are shown with 5 counters at

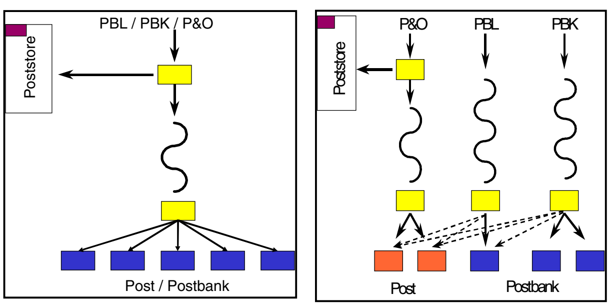

Figure 1: Pooling or Not

Table 2: Waiting Times per Service

Waiting time (in seconds) for 2 queuing protocols				
Products	Traffic %	Service time (sec.)	**Single-line** model	**Advisory** Model
POSTBANK Short	**45**	55	259	**84**
POSTBANK Long	13	115	259	254
POST Short	28	53	259	190
POST Long	2	102	259	190
Other	12	90	259	190

a 90% workload (as corresponding to rather realistic high traffic hours).

Based on queuing results to reduce the variation, a number of variants were proposed. The advisory model contains separate counters for short and long banking services as well as separate counters for postal jobs but with selective overflow possibilities and prioritizations. However, multi-server systems with different job preferences and overflow routing are analytically *nón- tractable.* Therefore, **simulations** had to be performed to compare the proposed variants. The results show that still significant reduction can be obtained for short jobs without paying a price, in fact even with small improvements, for other.

5 APPLICATION 2: BPR (CASE 2)

The trendy attention for BPR (*Business Process Redesign*) is largely focused at increasing the efficiency of employees and resources, to be seen as the utilization of machines in production. However, the aspect of time is not at all reflected in efficiency.

5.1 Simulation and Queuing

Awareness of the aspect *time* and insights in how *delays* can be improved are thus essential even before a simulation is started. These insights are most helpful if not necessary to develop suggestions for alternative work layouts or protocol-changes such as for BPR-purposes. The alternatives, in turn, are then to be tested, compared and tuned by *simulation*. A hybrid usage of queuing insights and simulation should thus be tried for.

Simple queuing insights and awareness of the importance of variations in services and job types for delays to arise, in combination with queuing results, already lead to some general rules, which can be most helpful for BPR-purposes. By these rules a limited number of work layouts may so be suggested while without such rules (and queuing insights, no directions at all are clear, so that the possible work layouts can be astronomic.

However, as the complexity of total work layouts is far too complex for exact analysis, a final comparison of these different work layouts is still required. To this end, **simulation is essential.**

5.2 BPR of Administrative Processes

The company Levob is a middle-sized insurance company in Holland. The major activity of this company is to offer, set up and maintain life insurance's or pension plans for individual persons (product 1) or collectively for groups of employees at middle-sized companies (product 2) or large companies (product 3).

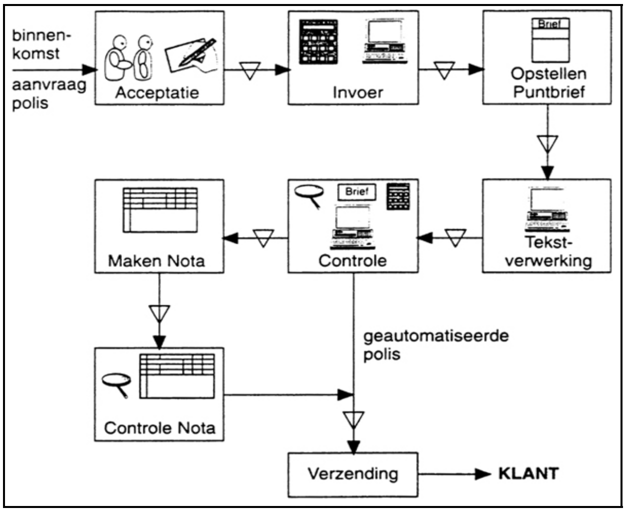

Figure 2: Process Overview

Some basic specifications for these products are listed in Table 3.

Table 3: Product Characteristics

Product	%	Type	Net Time	Effective	Profit
1	90%	Standard	1/2-1 hour	week	+
2	7%	Specialized	1-2 weeks	1-2 months	++
3	3%	Very Spec.	wks/months	months/yr	+++++

5.3 Results

Again, by general queuing insights regarding pooling, prioritization, and parallelization, a number of work layouts could be suggested. Below the performance results are shown as obtained by **simulation**. Here it is to be realized that these results are obtained by simulation while in reality for variant 1 extremely long process times of over one year will be avoided by "ad hoc" interventions.

Nevertheless, the results can be regarded as sufficiently indicative of the improvements that can be achieved.

Table 4: Results

Product	1	2	3
Starting Variant	6.24	9.03	646.15
Advisory Variant	**5.05**	**5.05**	**5.05**

6 APPLICATION 3: CALL CENTERS (CASE 3)

The development of call centers receives considerable attention in response to the current trend of customer-satisfaction and computerization. Two aspects of performance interest are:

1. An evaluation of the performance and required capacity (number of agents) of a call center
2. A flexible usage of capacities and skill based routing.

Both queuing theory and simulation are classically applied for the first purpose. However, the second purpose which becomes more important in newly developed computerized call centers, is still most open for research.

6.1 Case 3: HP-Helpdesk (Fig. 3)

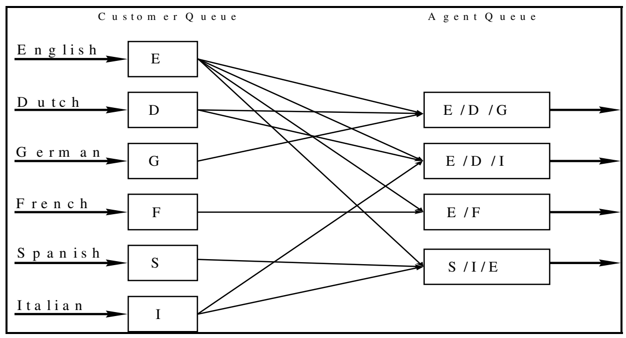

Figure 3: Helpdesk Routing

For example the Hewlett Packard European helpdesk center in Amsterdam has over 300 operators that speak two, three or four out of twenty different languages. How many operators and with which multi-lingual qualifications are to be set in to optimize the operator costs in relation with waiting times? And relatedly, when and how should calls be re-routed? In essence the latter question boils down, though in a far more complex form, to classical **unsolved overflow** problems in queuing, from which most useful insights can be adopted.

However, as overflow mechanisms cannot be handled just by formula, **simulation** to test and compare different of such skill based routing mechanisms is highly required.

7 APPLICATION 4: RAILWAYS (CASE 4)

Despite the fact that trains operate at fixed train schedules, train delays do arise for a variety of possible reasons. How can these delays be reduced or avoided by capacity expansions, what are the bottlenecks in the infrastructure, how quickly do these delays vanish or oppositely, how strongly do they proliferate within the railway network, are all typical questions of substantial practical and general interest, for which no simple answers can be provided. Extensive research will be required relying upon queuing insights and extensive simulation.

7.1 Case 4: A Railway Station (Figure 4)

For example, a railway station can in essence be regarded as a circuit switch queuing network, known from telecommunications, for which analytic queuing results are available under the 'lost' assumption, i.e., calls that cannot find a free route are rejected. Despite the fact that 'trains' can never be rejected, this model has shown useful for qualitative analysis of railway stations. However, to investigate the effect of the 'unnatural loss assumption' to justify the qualitative results for practice, as well as to study special additional features of practical railway scheduling, **simulation is required.**

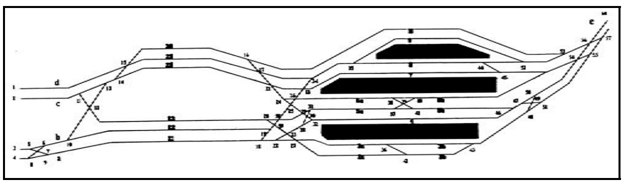

Figure 4: Representation of a Railway Station

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