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MEASUREMENT PRINCIPLES IN NETWORK MONITORING

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ABSTRACT

The paper classifies the measurement principles depending on the aim of measurement /diagnostics, performance and analysis/, and compares the information of network measurement and communication protocols.

АННОТАЦИЯ

В статье дается классификация принципов измерения сети вычислительных машин в зависимости от цели измерений /диагностика, определение мощности, анализ/, а затем сравнивается информация измерений сети ЭВМ с информацией коммуникационного протокола.

KIVONAT

A cikk a számitógéphálózatok mérési elveit osztályozza a mérés céljától függően /diagnosztizálás, teljesitőképesség meghatározás, analizis/, majd összehasonlitja a hálózatok mérésének és a kommunikációs protokolloknak az információ tartalmát.

HIERARCHY OF MEASUREMENTS

The measurement of computer networks can be characterized by three levels:

- diagnostics
- performance measurement
- analysis.

The first level brings the events into the focus, the second one the laws and the third one the validity of laws.

The Table gives a comparison of the three levels.

	DIAGNOSTIC MEASUREMENT	PERFORMANCE MEASUREMENT	ANALYTIC MEASUREMENT
PARAMETERS TO BE MEASURED	- current network configuration - current operational status	- time - throughput - capacity of the node stores - queues - utilization of resources	- average message delay, throughput, network load - optimization problems - packet error behaviour - line overhead
MODEL OF COMPUTER NETWORK	- rather simplified deterministic graph - directed and weighted graph	- probabilistic graph - probabilistic model described by Jackson - Jackson's model modified by Kleinrock - model based on Floyd's algorithm - decision model as an aid to routing	- performance models - model for sensitivity analysis - statistical validation model - inter-network models
WORKLOAD	- real, during normal operation - artificial traffic generator - time-controlled - event-controlled	- real, during normal operation - artificial traffic generators - test tape library with different message mixes, processing loads and test duration	- the same as in performance measurement - more sophisticated workloads for analyzing the correlation of parameters and the effect of connected networks
MEASURING METHODS	- additional parts of standard packets - special packets - digital measuring methods	- accumulated statistics - snapshot statistics - tracing - stochastic measurement methods	- the methods of stochastic measurements
MONITORS	- software - one or more hosts work as measurement center	- hybrid monitor systems with distributed activity - special hosts for monitoring	- the same as in performance measurement - complex method based on algorithm to decrease convolution error
EVALUATION	- data reduction - display of the state of network components - lists of elements near to overload - lists of erroneous components	- histograms - average values, moments - distributions	- joint density function - analytic model
ERRORS	- overhead - low monitor resolution - high monitor resolution	- the measurement disturbes or changes the quantities to be measured - sampling error - quantization	- propagation of errors - effect of the model - convolution errors
EXAMPLES	- ARPANET, the development of NCC - automatic monitor system of General Electric International Network	- one week of ARPANET - BISCOM store-and-forward message-switching system	- line overhead measurement of ARPANET - ALOHA

The purpose of diagnostic measurements is the control of correct operation of computer networks, the detection and diagnostics of errors. The operation of a computer network is characterized by events of different types.

The performance of a computer network means the quality and quantity of services in case of a given workload. The purpose of performance measurements is the analysis of effective operation under dynamically changing conditions.
The goal of analytic measurements is to understand the process in computer communication and their impact on the performance of the system.
The measure of analytic measurements is determined in the most general way by the joint density function of the performance probability variables (e.g. cross correlation function).

RELATIONSHIP BETWEEN PROTOCOLS AND MEASUREMENT

PROTOCOLS OF DIFFERENT LEVELS AND DIAGNOSTIC MEASUREMENT
Some parts of protocols can be used as a tool of diagnostics. Link level protocol (acknowledgement, cyclic redundancy check etc.), packet level protocol (receive ready, flow control etc.) and user level protocol (login, logout etc.).
COMPARISON OF PROTOCOL INFORMATION AND MEASUREMENT INFORMATION

Measurement information can be described by a conditional entropy

$$H(X/Y) = \sum_{i=1}^{n} \sum_{j=1}^{m} P(x_i, y_j) \log P(x_i/y_j)$$

X is the first message source (the quantity to be measured)

Y is the second source (the measured quantity).

The conditional entropy determines the measurement loss. If all message lengths have the same probability, the average transmitted information is

$$H(Y) = {}_2\log n$$

If the network is packet-switched, the maximum value of average transmitted information is

$$I(X,Y)_{MAX} = {}_2\log n_e$$

A protocol can be considered as a source code for representing control information. Gallager showed that the average protocol information per message is

$$\frac{1}{\varepsilon} H(\varepsilon) + \frac{1}{\delta} H(\delta) \quad \text{bits}$$

If the average transmission delay is given by d, the transmitted protocol information per message must be at least

$$-{}_2\log(1-e^{-\alpha d}) + \frac{1}{\varepsilon} H(\varepsilon)$$

SUMMARY

The paper gives a scope of computer metwork measurement. The well-articulated discussion - based on measurement hierarchy - makes easier to understand the measurement purposes, the methods and tools of measurement and the restrictions. The measurements were illustrated by up-to-date examples. Finally the relation between protocols and diagnostics was discussed and the protocol information and measurement information were compared.

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