*International Civil Aviation Organization*

**Aeronautical Telecommunication Network
Implementation Coordination Group – Seventh
Working Group Meeting (ATNICG WG/7)**

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# AMHS Performance Assessment in the Asia/Pacific Region (Draft)

(Presented by Japan)

| **SUMMARY** |
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| The paper describes the AMHS Performance Assessment in the Asia/Pacific Region |

## 1.    General

1.1        The description on AMHS Performance Assessment in the Asia/Pacific region is drafted and given as an attachment to the paper. In the attachment, after stating the objectives and scope of the document, the performance indicators of the AMHS Performance Assessment are proposed.

1.2        The AMHS Performance Assessment activities at the State level, the bilateral between States, and the regional/global level are also proposed together with the targets of these proposed performance indicators.

1.3        Some other issues are given at the end.

## 2.    Action by the meeting

2.1        The meeting is invited to review the attached document and revise it as necessary.

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Attachment

AMHS Performance Assessment in the Asia/Pacific Region (Draft)

## 1. Background

In the Asia/Pacific region, the States have been installing the Aeronautical Message Handling System (AMHS) for interconnections to the networked AMHSs. In general, performance issues are major concerns of system operations after a system is installed and running, even if the system is stand-alone. In many cases, the system (or subsystem) is interconnected one to the others, and the performance issues of networked operations are further complicated than the ones of stand alone system because of interactions among these systems. Such is the case of the AMHS, where the messaging services are based on the interconnections among the AMHSs, where each AMHS is managed by different authority.

Although the States have been expressing their concerns on the AMHS performance, it is not obvious to recognize how to handle the performance issues. In order to address the AMHS performance issues properly, it is required to take into considerations of

1) the nature of the AMHS together with its networked operations,

2) the nature of AMHS performance,

3) the performance indicators to characterize the AMHS performance, and

4) the required activities related to the AMHS performance.

Since the detailed documents on the AMHS itself, 1) shown above, are available somewhere else, here it is necessary to address only the topics 2)-4) related to the AMHS performance.

## 2. Objectives of AMHS Performance Assessment

Why it is necessary to consider the AMHS Performance at the regional level? The States in the region develop and/or deploy the AMHS complied with the Standards; including SARPs, Regional ICD and others. Such Standards specify the functionality of the AMHS, mainly for the inter-operability among the AMHSs. The conformance test verifies the compliance of the AMHS system, but it is not used for assessing the AMHS performance. The AMHS is required to be assessed whether it is efficient and effective or not. It is necessary for each State to assess the performance of deployed AMHS as a local activity. It is also necessary to assess the networked AMHS operations performance as a whole in the region, since the major services provided by the AMHS are messaging services among the installed AMHSs and the performance of the networked AMHS can not be assessed by individual State alone as a local activity. The assessment activities at regional level require coordination among States in the region.

The objectives of the document are to clarify the AMHS performance assessment by providing descriptions of performance indicators; what are to be assessed, and the performance assessment; how these performance indicators to be assessed, in the Asia/Pacific region.

## 3. Scope of AMHS Performance Assessment

It is necessary to focus our attentions to relevant scope of the topic; 'AMHS Performance Assessment'. The scope of the topic can be divided into three domains of scope; what is the AMHS performance, how the AMHS performance assessment handled, and where the AMHS performance assessment conducted. The topic is further focused in each domain of Information(Performance Indicators), Procedure(Performance Assessment) and Organization(State and Region).

### 3.1 Informational Scope of AMHS Performance Assessment

It is necessary to identify the information relevant to the AMHS Performance Assessment. The materials from two different sources are used for references.

a) RCP Type Parameters

'ICAO Manual on Required Communications Performance (RCP)' describes the RCP type parameters as follows:

    ①     *Communication transaction time - The maximum time for the completion of the <u>operational</u>*

*communication transaction* after which the initiator should revert to an alternative procedure.

②     *Continuity - The probability that an operational communication transaction can be completed within the communication transaction time.*

③     *Availability - The probability that an operational communication transaction can be initiated when needed.*

④     *Integrity - The probability that communication transactions are completed within the communication transaction time with undetected error.*

    An *operational communication transaction is defined as 'the process a human or system uses to send and/or receive an instruction, clearance, flight information, and/or request, and is completed when the human is confident that the transaction is satisfactorily complete'.*

    The problem to use the parameters listed above, especially 'communication transaction time' is that

(1)    'the (operational communication) transaction' is defined as a process of including 'send and receive' messages, meaning two-way communication,

(2)    'the initiator should revert to an alternative procedure' if such a transaction is not completed within the specified time, where an alternative procedure is implied voice communication.

    In the AMHS, there is no concept 'response time' nor 'maximum time of completion' of messaging. The RCP is suitable to be applied for time critical and two-way communication, like ATC Air/Ground communication or AIDC, but not AMHS.

    By the same reason, the 'continuity' parameter is not suitable for the AMHS performance assessment, since 'be completed within the communication transaction time' can not be assessed in the AMHS environment.

    It should be noted that the 'integrity' can be assessed only when an error is detected, since we can not assess the integrity where an error is not detected. The undetected errors could be avoided by detecting defects during the conformance testing.

    b)    Quality of Services

    Since the RCP type parameters are not necessary satisfactory for the AMHS performance assessment, it is necessary to find suitable parameters, especially time related ones, for the AMHS performance assessment.

    Another general source describes that the major requirements for supporting QoS (Quality of Service) in services are as follows:

①*Availability: Availability is the quality aspect of whether the service is present or ready for immediate use.*

②*Accessibility: Accessibility is the quality aspect of a service that represents the degree it is capable of serving a service request.*

③*Integrity: Integrity is the quality aspect of how the service maintains the correctness of the interaction in respect to the source.*

④*Performance: Performance is the quality aspect of service, which is measured in terms of throughput and latency. Higher throughput and lower latency values represent good performance of a service. Throughput represents the number of service requests served at a given time period. Latency is the round-trip time between sending a request and receiving the response.*

⑤*Reliability: Reliability is the quality aspect of a service that represents the degree of being capable of maintaining the service and service quality. The number of failures per month or year represents a measure of reliability of a service. In another sense, reliability refers to the assured and ordered delivery for messages being sent and received by service requestors and service providers.*

⑥*Regulatory: Regulatory is the quality aspect of the service in conformance with the rules, the law, compliance with standards, and the established service level agreement.*

⑦*Security: Security is the quality aspect of the service of providing confidentiality and non-repudiation by authenticating the parties involved, encrypting messages, and providing access control.*

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The terms listed above are considered as the parameters of 'required quality of services'. The parameters, 'Availability', 'Accessibility', 'Integrity', and 'Reliability' are almost equivalent to the RCP type parameters, while 'Regulatory' and 'Security' are out of scope of the AMHS performance assessment.

The 'Performance' parameter includes 'Throughput' and 'Latency' where the 'Latency' is the round-trip time between sending a request and receiving the response, is not suitable to be applied for AMHS performance assessment.

It should be noted that the performance in the first reference, RCP document, is the 'operational performance', instead of the 'technical performance' (e.g. VDL, SATCOM), and the performance in the second reference is the service performance, instead of system performance.

By modifying the referred descriptions, the information for the AMHS performance assessment includes the followings:

① Availability - The probability that an AMHS service request can be initiated when needed.
② Integrity - The probability that an AMHS service request is completed without detected error(s), where the error includes the message delivery error and delivered message error.
③ Throughput - The number of service requests served at a given time period.
④ Transmission - The time between sent and received by message sender and message receiver.

## 3.2 Procedural Scope of AMHS Performance Assessment

After the AMHS performance and the performance indicators are understood, the next topic is how to handle the AMHS performance using such indicators. The AMHS, or any other system, goes through the life cycle processes of planning, development/deployment and operation/maintenance. The AMHS performance assessment is mainly at the operational stage of the AMHS life.

Identifying the AMHS performance indicators, more detailed activities related to the AMHS performance assessment should be elaborated, including performance measurements and evaluation. Based on the defined/determined performance indicators, the AMHS performance will be measured. Based on the measured AMHS performance, the AMHS performance is assessed. Before assessing the AMHS performance, it is required to set a target of the AMHS performance, in terms of the AMHS performance indicators which are compared against the measured performance values.

The assessment activities include confirming the performance indicators, setting a target at the planning stage, and measuring the performance, evaluating the performance at the operational stage.

## 3.3 Organizational Scope of AMHS Performance Assessment

The topic; 'AMHS Performance Assessment' is discussed in the regional group. The major concern of the group is the 'AMHS Performance Assessment' in the Asia/Pacific region. Although the scope of the topic should be focused to the regional matter, it is unrealistic to assume AMHS Performance Assessment in the Asia/Pacific region without any AMHS Performance Assessment in individual State.

Organizationally, the States in the Asia/Pacific region are involved in the AMHS Performance Assessment in the Asia/Pacific region, and sometime it may need the bilateral coordination between States.

## 4. Performance Indicators Related to AMHS Performance Assessment

The performance indicators are listed in Table 1. The detailed descriptions are given as follows;

Table 1 Performance Indicators of AMHS Performance

| Performance Indicator Category | Candidate Performance Indicators | States | Bilateral between States | Regional/ Global | Remarks |
|---|---|---|---|---|---|
| Availability | MTBF/MTTR | x | | | |
| Integrity | Quality of Message Delivery | x Note 2 | x Note 2 | x Note 2 | |
| | Quality of Message Delivered | x Note 2 | x Note 2 | x Note 2 | |
| Throughput: Demand of messaging | In-bound (receiving) message demand | x | x Note 1 | x Note 1 | throughput (time varying) |
| | Out-bound (sending) message demand | x | | | throughput (time varying) |
| Throughput: Capacity of AMHS server | | x | | | Throughput (fixed, max # of messages able to be handled) |
| Transmission Time (Delay) | sender message-out to receiver message-in | x | x Note1 | | Time per message |

Note 1: Although the message demand and time for transmission may not require the coordination at the level of regional/global or bilateral between States, it is useful to provide the in-bound demand characteristics, for instance in hourly basis, at each receiving AMHS server for predicting the time for transmission at the sender. The detailed discussions will be provided in the later section.

Note 2: The integrity indicators at the regional level are to assess the integrity as a whole in the region, while the performance assessment activities at the State and bilateral level include the resolution of performance issues, if there are any.

4.1 Availability

The availability can be assessed by counting the number of failed service invocations, or by using MTBF(mean time between failures) or MTTR (mean time to repair). These indicators can be applied to the individual AMHS server, but it is hard to conceive the availability of the networked AMHS as a whole.

4.2 Integrity

There are two possible AMHS performance indicators related to the integrity. They are the quality of message delivery and the quality of delivered message. Since message delivery is an activity between servers, the assessment of integrity requires at least coordination among the States in the region.

4.2.1 Integrity: Quality of Message Delivery

The quality of message delivery indicates either how many messages out of the messages sent are undelivered to the intended recipients, or how many messages out of the messages sent are delivered to the intended recipients.

It should be noted that the delivered/undelivered should be detected by the AMHS. The undetected un-delivery is excluded from the performance assessment. Also excluded are the messages delivered to the incorrect recipients.

The undetected message delivery should be tested as a part of the conformance test.

4.2.2 Integrity: Quality of Message Delivered

The quality of message delivered indicates either how many messages out of the messages received have the (detected) errors, or how many messages out of the messages received have no (detected) errors.

The undetected message errors should be tested as a part of the conformance test.

### 4.3 Throughput: Demand of messaging

The demand of messaging indicates the number of messages received and sent at each AMHS server. The demand changes during the operational hours so that the demand should be monitored accordingly, say for every one hour. The messaging demand between specific pair of AMHS servers may be monitored, but for the performance assessment purpose, it is more important to have the total number of messages to be received and sent at the AMHS server than message traffics between one specific pair of AMHS servers.

There are two classes of messaging demand,

- In-bound message demand
- Out-bound message demand.

The classifying demands into in-bound and out-bound, is important to characterize the messaging demand, since the peak demands of in-bound and out-bound messaging may differ during the operation. The in-bound message demand at one AMHS server may influence the transmission time of messages received at the AMHS server. The classification also helps to identify the capacity of the AMHS server, handling mixture of in-bound and out-bound demands, shown below.

In any case, it is not necessary to assess the messaging demand at the regional level, except to collect the statistics of messaging demand as a whole in the region.

### 4.4 Throughput: Capacity of AMHS server

The capacity of AMHS server indicates the ability to handle the number of messages in the service. The capacity of AMHS server may be visible when the messaging demand is close to or exceeds the capacity. The excess demand will cause delays in messaging services. By classifying messaging demands into in-bound and out-bound, it is easy to identify which one is dominant during the most heavily loaded time period.

It is the States' responsibility to identify the capacity of their AMHS servers.

### 4.5 Time Efficiency; Time for Transmission (Delay)

The time for transmission (delay) indicates the time interval required to transmit individual message, while the demand and the capacity given above are throughput, collective messaging performance of all messages received/sent at the AMHS server site.

The transmission time can be defined as the time from one server output to another server input
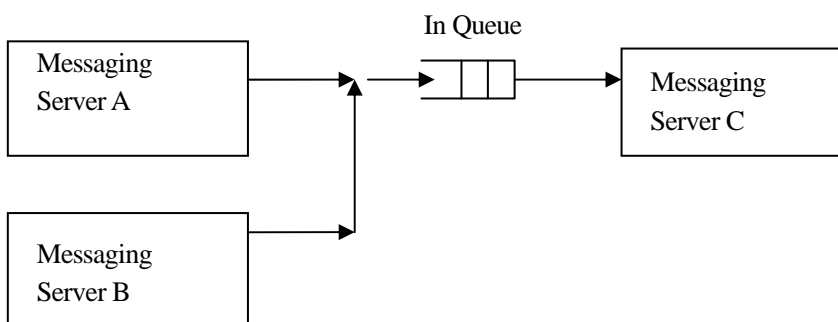


Fig.1 Messaging Servers and Input Queue

The figure shows the input queue at an AMHS server. In an actual implementation of AMHS server, the sender AMHS server would test availability of the receiver AMHS before sending messages, instead of put messages in the input queue. But it is easy to model and understand such a situation by using input queue.

The time interval from one server output to another server input, may include the time for establishing connection/association between AMHS servers, and actual message transmission time.

The message transmission time may be large if the message is longer or the communication infrastructure is slow, while the time before transmission may increase if the many messages are competing to be received at the same destination AMHS server. The message transmission time is almost fixed or predictable once the message to be sent is given, while the time before transmission may change depending on the dynamic operating environment at the receiving site.

A server, e.g. Server A in Fig. 1 sends messages to a server e.g. Server C in Fig. 1, without knowing the messaging demands originating at other sender messaging servers, e.g. Server B in Fig. 1, destined to the same receiver messaging server, e.g. Server C, a messaging request from one sender messaging server, e.g. Server A, may have to wait for longer time to be accepted by the receiver messaging server.

Since the messaging service scheme is the store-and-forward, there is no assurance for the messaging service to satisfy any time related requirements. Therefore, there is no meaning to relate the messaging service performance to any required performance.

Note: The AMHS messaging discussed here is the one-way message transmission, instead of two-way dialogue, so that there is no concept of 'response time' in the AMHS messaging. The time for transmission should not be confused with the response time, where the response time include two way transmission possibly including human factors in between, like the RCP proposed in the ICAO document.

Still, there exist constant requests in the region to evaluate the messaging services performance as the regional practices. In order to predict or evaluate the time mentioned above properly, it is necessary to know the in-bound demand at the receiving site.

## 5. AMHS Performance Indicators and their Assessment

In the section, the performance indicators and their related activities at the regional level, bilateral basis between States and the State level are proposed.

## 5.1 AMHS Performance Indicators and their Assessment at Regional Level

As described in the previous sections, performance indicators related to the capacity of messaging servers and the demand of messaging services have be captured properly, but these are managed locally at messaging service sites.

In the following, the AMHS performance indicators at the regional level are proposed, first the indicator on the time for transmission at the regional level, followed by quality on message delivery and quality of delivered messages.

## 5.1.1 Quality on Message Delivery

The quality of message deliveries can be monitored by the number of NDRs (Non Delivery Reports) per a day, week or month within the region. Since the many messaging servers are involved in the message delivery, the quality on message deliveries has to be assessed as a regional matter rather than as an individual State matter. The region has to decide the level of acceptable quality.

## 5.1.2 Quality of Delivered Message

Similar to the quality on message deliveries, the quality of delivered messages, the number of messages with detected errors, has to be assessed as a regional matter.

## 5.2 In-bound Demand (at Receiver)

The States may need to know the in-bound demand at the sites of intended message recipients.

If a sender knows the in-bound traffic during certain hour of operation at the recipients, the sender may be able to measure and assess the time efficiency by some means. Without knowing the information, senders will not be able to identify which hour the recipients are in the busiest. The information can be provided in a relative scale as an in-bound demand profile, i.e. which hour is the busiest, rather than the absolute number of messages arriving at the site during a certain hour. The information is the collective one that there is no need to be broken down to the

in-bound demand of between server pairs. Also there is no need to provide the out-bound demand, since it is no used for measurements for time efficiency.

a) Scheme to Inform In-Bound Demand at Receiving Sites

It should be noted that demand and capacity at all sites have to be analyzed before performance evaluation. Without knowing the operating environment, it is useless to conduct performance evaluation. There should also be a scheme to inform the total (possibly time varying) in-bound demand at each site from all other sites. The scheme may be provided as bilateral basis but a common scheme in the region is advisable. It should be also noted 'the total (possibly time varying) in-bound demand at any partner site from all other sites' can not be derived by '(possibly time varying) out-bound demands from each site to any direct MTA partners'.

5.3 AMHS Performance Indicators and Related Activities at State level

The following indicators are suggested for local performance assessment. These indicators are not required or are not necessary for other sites to know or to conduct their performance evaluation.

a) Availability

The performance assessment on availability of each AMHS is the responsibility of each State. The performance assessment on availability of AMHS as a whole in the Asia/Pacific region is not discussed in the document.

b) Integrity

The integrity of messaging services, in terms of quality of message delivery and quality of delivered message, should be assessed by the States as well as at the regional level. The purpose of integrity assessment at the State level and the regional level is different. The integrity issues of the States level or between two States should be resolved through the integrity assessments at the State level or between States, while at the regional level, the integrity of the messaging services within the region is assessed.

c) Demand

The numbers of in-bound and out-bound demands have to be monitored together with the demand variation during day, or week, if any.

d) Capacity

It is important to know the capacity of the server in its operations. The capacity can be detected by finding the peak demand for in-bound and out-bound.

e) Time Efficiency

Primarily, it is State's responsibility to assess the time efficiency of operation locally, but States may need the help of other States, the communicating partners, to provide the scheme to assess the time efficiency.

5.4 Summary: Proposed AMHS Performance Indicators and their Assessment in Asia/Pacific region

5.4.1 Deriving 'Number of Messages'

In order to avoid misunderstanding of the descriptions given above, some formal notations are used in the section to describe the derivation of number of messages used in the document. There are differences in descriptions between two documents; the AMHS Messaging Management Manual and Asia/Pacific AMHS Performance Assessment, as shown below.

M is the set of MTAs in the Asia/Pacific region.
$\qquad$ M ::= { M(i), i=1..n }, M is defined as a set of M(i)s: MTA at site i in the Asia/Pacific region.

D(i, j) = true,　if M(i) and M(j) are direct MTA partners,
$\qquad$ =false,　otherwise.
$\qquad$ If D(i,j) is true, then D(j,i) is also true

T(i,j,t,d) is the number of messages transmitted from M(i) to M(j) where D(i, j) = true, during Day= d in Hour = t, where d and t are in UTC.
R(i,j,t,d) is the number of messages received from M(j) to M(i) where D(i, j) = true, during Day= d in Hour = t, where d and t are in UTC.
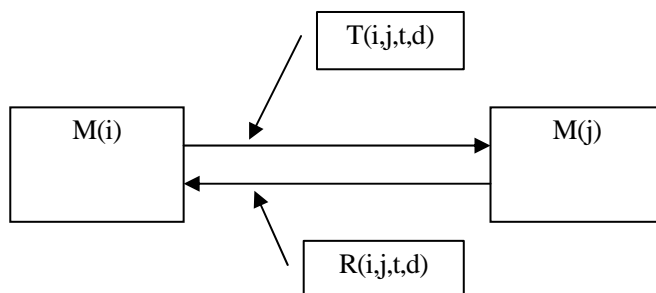


Fig. 3 Messaging between direct MTA partners

Note: *, @, + indicate accumulation of numbers over Hours in one day, over direct MTA partners, and over days in one month, respectively.

a) Number of messages transmitted

$T*(i,j,d) = T(i,j,1,d) + T(i,j,2,d) + .. + T(i,j,24,d)$
$\qquad$ is the number of messages transmitted from M(i) to M(j) where D(i, j) = true, during Day= d from Hour = 1 to Hour= 24 in UTC.
$T^{@}(i,t,d) = T(i,1,t,d) + T(i,2,t,d) + .. + T(i,n,t,d)$, where n is the number of direct MTA partners to M(i),
$\qquad$ is the number of messages transmitted from M(i) to all M(j)s where D(i, j) = true, during Day= d in Hour = t in UTC.
$T^{*+}(i,j) = T* (i,j,1) + T* (i,j,2) + .. + T* (i,j,m)$
$\qquad$ is the number of messages transmitted from M(i) to M(j) where D(i, j) = true, during one month from Day = 1 to the day m at end of the month in UTC.
$T^{@}* (i,d) = T^{@} (i,1,d) + T^{@} (i,2,d) + .. + T^{@} (i,24,d)$
$\qquad$ is the number of messages transmitted from M(i) to all M(j)s where D(i, j) = true, during Day= d from Hour = 1 to Hour=24 in UTC.
$T^{@+} (i,t) = T^{@} (i,t,1) + T^{@} (i,t,2) + .. + T^{@} (i,t,m)$
$\qquad$ is the number of messages transmitted from M(i) to all M(j)s where D(i, j) = true, in Hour = t during one

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month from Day = 1 to the day m at end of the month in UTC.

$$T^{@}*^{+}(i) = T^{@}*(i,1) + T^{@}*(i,2) + .. + T^{@}*(i,m)$$

is the number of messages transmitted from M(i) to all M(j)s where D(i, j) = true, during one month from Day = 1 to the day m at end of the month in UTC.

$P_{transmitted}(i, j, d) =k$ ; Peak Hour k of the number of messages transmitted from M(i) to M(j) during Day= d where D(i, j) = true, is the Hour =k is t=k such that $T(i,j,k,d) = Max_t\{ T(i,j,t,d), t=1..24 \}$

$P^{+}_{transmitted}(i, j) =k$ ; Peak Hour k of the number of messages transmitted from M(i) to M(j) in one month where D(i, j) = true, is the Hour =k is t=k such that $Max_d Max_t \{ T(i,j,t,d), t=1..24, d=1..m \}$

$P^{@}_{transmitted}(i,d) =k$, Peak Hour k of the number of messages transmitted from M(i) to all M(j)s during Day= d where D(i, j) = true, is the Hour =k is t=k such that $T^{@}(i,k,d) = Max_t\{ T^{@}(i,t,d), t=1..24 \}$

$P^{@}*^{+}_{transmitted}(i) =k$, Peak Hour k of the number of messages transmitted from M(i) to all M(j)s in one month where D(i, j) = true, is the Hour =k is t=k such that $Max_d Max_t\{ T^{@}(i,t,d), t=1..24, , d=1..m \}$
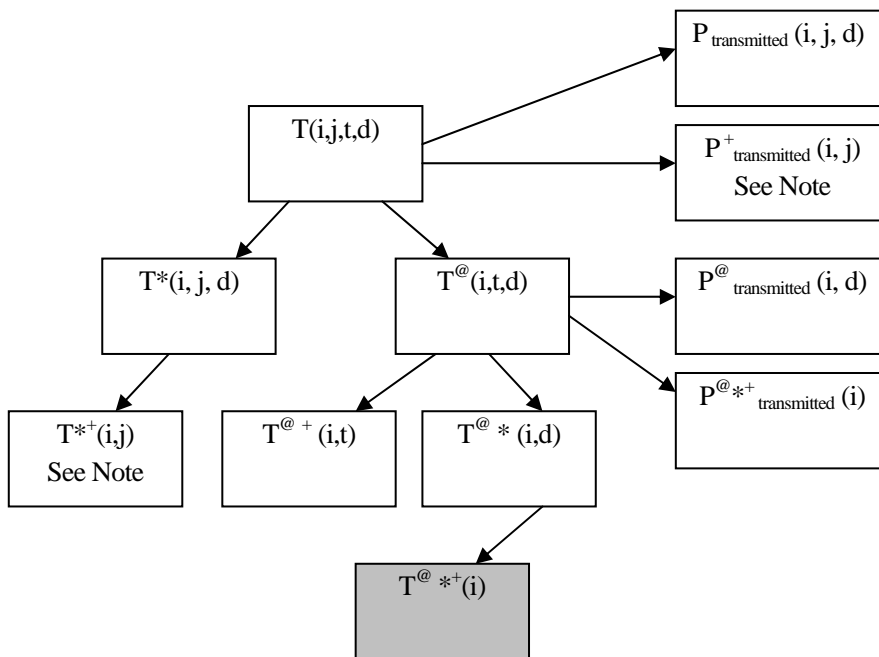


Fig.4 Tree for deriving statistical data 'Number of data messages transmitted'

Note: Two statistical data listed in the AMHS Messaging Management Manual are

*Number of data messages transmitted*

- *data corresponding to the peak hour traffic over the past month,*
    $Max_d Max_t \{ T(i,j,t,d), t=1..24, d=1..m \}$ where Peak Hour t=k is $P^{+}_{transmitted}(i, j) =k$,given above.
- *total data corresponding to the daily traffic over the past month.*
    $T*^{+}(i,j)$.

Fig.4 shows the derivation of statistical data shown above. All these statistical data are not necessary derived.

b) Number of messages received

R(i,j,t,d) is the number of messages received from M(j) to M(i) where D(i, j) = true, during Day= d in Hour = t, where d and t are in UTC.

$$R*(i,j,d) = R(i,j,1,d) + R(i,j,2,d) + .. + R(i,j,24,d)$$

is the number of messages received from M(j) to M(i) where D(i, j) = true, during Day= d from Hour =

1 to Hour= 24 in UTC.

$R^@(i,t,d) = R(i,1,t,d) + R(i,2,t,d) + .. + R(i,n,t,d)$, where n is the number of direct MTA partners to M(i), is the number of messages received at M(i) from all M(j)s where D(i, j) = true, during Day= d in Hour = t in UTC.

$R^{*+}(i,j) = R^*(i,j,1) + R^*(i,j,2) + .. + R^*(i,j,m)$
is the number of messages received from M(j) to M(i) where D(i, j) = true, during one month from Day = 1 to the day m at end of the month in UTC.

$R^@*(i,d) = R^@(i,1,d) + R^@(i,2,d) + .. + R^@(i,24,d)$
is the number of messages received at M(i) from any M(j)s where D(i, j) = true, during Day= d from Hour = 1 to Hour=24 in UTC.

$R^{@+}(i,t) = R^@(i,t,1) + R^@(i,t,2) + .. + R^@(i,t,m)$
is the number of messages received at M(i) from all M(j)s where D(i, j) = true, in Hour = t during one month from Day = 1 to the day m at end of the month in UTC.

$R^{@*+}(i) = R^@*(i,1) + R^@*(i,2) + .. + R^@*(i,d)$
is the number of messages received at M(i) from all M(j)s where D(i, j) = true, during one month from Day = 1 to the day m at end of the month in UTC.

$P_{received}(i, j, d) = k$ ; Peak Hour k of the number of messages received from M(j) to M(i) in Day = d where D(i,j) = true, is the Hour =k is t=k such that $R(i,j,k,d) = Max_t\{ R(i,j,t,d), t=1..24 \}$

$P^+_{received}(i, j) = k$ ; Peak Hour k of the number of messages received from M(j) to M(i) in one month where D(i, j) = true, is the Hour =k is t=k such that $Max_d Max_t \{ R(i,j,t,d), t=1..24, d=1..m \}$

$P^@_{received}(i,d) = k$, Peak Hour k of the number of messages received from all M(j)s to M(i) during Day= d where D(i, j) = true, is the Hour =k is t=k such that $R^@(i,k,d) = Max_t\{ R^@(i,t,d), t=1..24 \}$

$P^{@*+}_{received}(i) = k$, Peak Hour k of the number of messages received from all M(j)s to M(i) in one month where D(i, j) = true, is the Hour =k is t=k such that $Max_d Max_t\{ R^@(i,t,d), t=1..24, d=1..m \}$
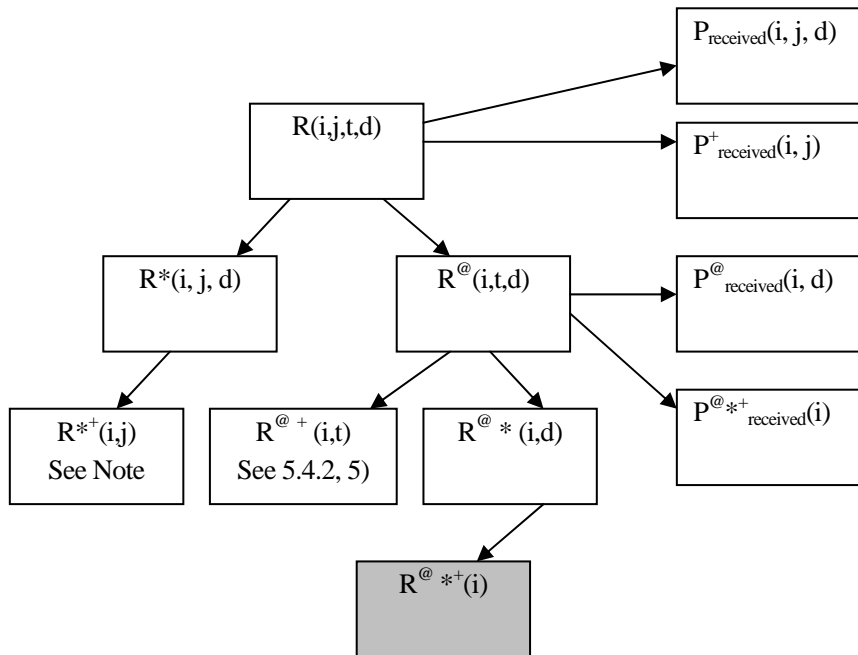


Fig. 5 Tree for deriving statistical data 'Number of data messages received'

Note: Two statistical data listed in the AMHS Messaging Management Manual are
*Number of data messages received*
● *data corresponding to the peak hour traffic over the past month,*

$\text{Max}_d\text{Max}_t \{ R(i,j,t,d), t=1..24, d=1..m \}$ where Peak Hour is $P^+_{received}(i, j) =k$

- *total data corresponding to the daily traffic over the past month.*

    $R*^+(i,j)$

c) Number of all (transmitted and received) messages

$S(i,j,t,d) = T(i,j,t,d) + R(i,j,t,d)$   is the number of all (transmitted and received) messages between M(i) and M(j) where D(i, j) = true, during Day= d in Hour = t, where d and t are in UTC.

$S*(i,j, d) = T*(i,j, d) + R*(i,j, d)$

is the number of all (transmitted and received) messages between M(i) and M(j) where D(i, j) = true, during Day= d from Hour = 1 to Hour= 24 in UTC.

$S^@ (i,t, d) = T^@ (i,t, d) + R^@ (i,t, d)$

is the number of all (transmitted and received) messages at M(i) to/from all M(j)s where D(i, j) = true, during Day= d in Hour = t in UTC.

$S*^+ (i,j) = T*^+ (i,j) + R*^+ (i,j)$

is the number of all (transmitted and received) messages between M(i) and M(j) where D(i, j) = true, during one month from Day = 1 to the day m at end of the month in UTC.

$S^{@+} (i,t) = T^{@+} (i,t) + R^{@+} (i,t)$

is the number of all (transmitted and received) messages at M(i) to/from all M(j)s where D(i, j) = true, in Hour = t during one month from Day = 1 to the day m at end of the month in UTC.

$S^{@}*^+ (i) = T^{@}*^+ (i) + R^{@}*^+ (i)$

is the number of messages all (transmitted and received) at M(i) to/from all M(j)s where D(i, j) = true, during one month from Day = 1 to the day m at end of the month in UTC.

$P_{sum}(i, j, d) =k$ ; Peak Hour k of the number of all (transmitted and received) messages between M(i) and M(j) in Day =d where D(i, j) = true, is the Hour =k is t=k such that $S(i,j,k,d) =\text{Max}_t\{ S(i,j,t,d), t=1..24 \}$

$P^+_{sum}(i, j) =k$ ; Peak Hour k of the number of all (transmitted and received) messages between M(i) and M(j) in one month where D(i, j) = true, is the Hour =k is t=k such that $\text{Max}_d\text{Max}_t \{ S(i,j,t,d), t=1..24, d=1..m \}$

$P^@_{sum} (i,d) =k$, Peak Hour k of the number of all (transmitted and received) messages at M(i) to/from all M(j)s in Day =d where D(i, j) = true, is the Hour =k is t=k such that $S^@ (i,k,d) =\text{Max}_t\{S^@ (i, t,d), t=1..24 \}$

$P^{@}*^+_{sum} (i) =k$, Peak Hour k of the number of all (transmitted and received) messages at M(i) to/from all M(j)s in one month where D(i, j) = true, is the Hour =k is t=k such that $\text{Max}_d\text{Max}_t\{ S^@ (i,t,d), t=1..24, d=1..m \}$

5.4.2 AMHS Performance Indicators

Proposed AMHS Performance Indicators are tabulated in the following table. The first two indicators are also listed as a part of statistics to be collected in the AMHS Messaging Management Manual.

Table 2    Proposed AMHS Performance Indicators

| Indicators |
| --- |
| 1) Number of messages transmitted |
| 2) Number of messages received |
| 3) Number of non-delivery reports received |
| 4) Number of received messages with detected error(s) |
| 5) Hourly profile of received message traffic in one day |

1) Number of messages transmitted

$$T^{@} *^{+}(i)$$

Note: The statistics listed in the AMHS Management Manual include 'Number of data messages transmitted', instead of 'Number of messages transmitted'. The difference between them means that whether the number of non-data messages, e.g. control messages, is included or not. In order to assess performance, the number of messages is proposed as one of indicators in the document.

2) Number of messages received

$$R^{@} *^{+}(i)$$

Note: The statistics listed in the AMHS Management Manual include 'Number of data messages received', instead of 'Number of messages transmitted'. The difference between them means that whether the number of non-data messages, e.g. control messages, is included or not. In order to assess performance, the number of messages is proposed as one of indicators in the document.

3) Number of non-delivery reports received

The number of non-delivery reports received *at the origin of (editor's note)* the message is collected at the end of each month and reported. The number of non-delivery reports among the number of messages transmitted is evaluated as a messaging quality and assessed for satisfying the quality target.

Editor's note: To be studied further.

4) Number of received messages with detected error(s)

The number of received messages with detected error(s) in one month is collected at the end of each month and reported. The error detection should be limited to the errors in protocol, not the message contents. The number of *received (editor's note)* messages with detected error(s) among the number of messages received is evaluated as a messaging quality and assessed for satisfying the quality target.

Editor's note: To be studied further.

5) Hourly profile of received message traffic in one day

Hourly profile of received message traffic in one day can be derived using $R^{@+}(i,t)$ statistics given in Fig.5

5.4.3 AMHS Performance Data Collection and Assessment

The following procedure for statistical data collection and assessment is proposed.

a)   Collect daily traffic data on 'Number of messages transmitted' $T^{@} * (i,d)$ and 'Number of messages received' $R^{@} * (i,d)$. If $T* (i,j,d)$ and $R * (i,j,d)$ are collected as indicated in the AMHS Messaging Management Manual, generate $T^{@} * (i,d)$ and $R^{@} * (i,d)$.

b)   Collect and report 'Number of non-delivery reports received' and 'Number of received messages with detected error(s)' in one month. 'Number of non-delivery reports received'/'Number of messages transmitted' and 'Number of received messages with detected error(s)'/'Number of messages received' should be also reported to the regional group.

c)   'Hourly profile of received message traffic in one day' for t=1..24 can be reported as $R^{@+}(i,t)$ given above, say once in a year, to the regional group for helping any direct MTA partners to conduct time efficiency evaluation at their convenient time.

6. Target of Performance Indicators

After agreeing the selection of performance indicators, the target values of performance indicators have to be determined. In the document, the following values are tentatively proposed as the target of each performance indicator.

Table 3 (Proposed) Target Values of Performance Indicator

| Performance Indicator | Target |
|---|---|
| Quality of Message Delivery (detected message un-delivery) | less than or equal to $10^{-4}$ |
| Quality of Delivered Message (detected error rate) | less than or equal to $10^{-4}$ |

7. Some Issues other than AMHS Performance Assessment at Regional Level

7.1 AMHS Performance Assessment during Transition Period: AMHS, AFTN and AMHS+AFTN

In the previous sections, we considered only the AMHS performance, but in reality, there are AMHS services as well as AFTN services concurrently as depicted in Fig.6, although two services are isolated by the gateway function.

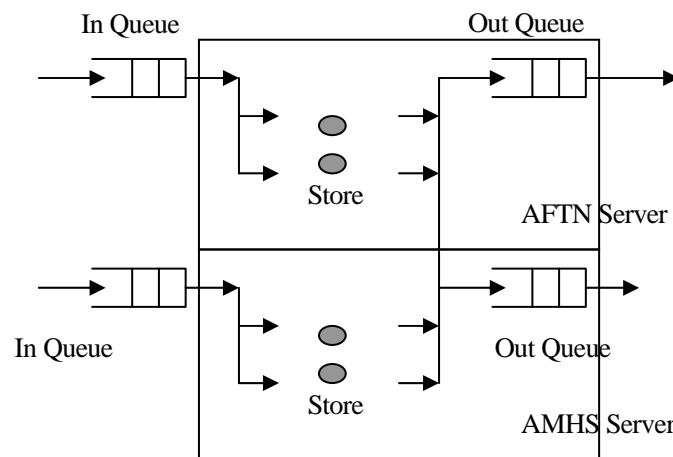It is recommended to evaluate their performance separately between two services.

Fig.6 AFTN and AMHS server

Since the AMHS and the AFTN services co-exit in the region, the messages cross the boundary between two services. In some cases, the performance of both services may be reflected to the AMHS performance indicators, for instance the NDR crosses the boundary. The AMHS performance indicators may show more errors than the AFTN, since the message checking by the AMHS is stronger than the AFTN message checking. As far as the message originated at the AMHS sites, it should be considered as the part of the AMHS services, even if the messages cross the boundary of two services.

7.2 AMHS Performance Assessment across Regional Boundaries

The messages may cross the regional boundaries to other regions. As far as the message originated at the AMHS sites in the Asia/Pacific region, it should be considered as the part of the AMHS services in the region, even if the messages cross the boundaries of regions.

7.3 Performance Assessment at Network/Data Link Level below Messaging Services

Some concerns are expressed on the performance issues below the AMHS messaging services. Especially, in order to evaluate the AMHS performance, it is argued that some measures, like communication line loading as the AFTN performance assessment, are desirable, but it is not feasible. In the section, the reasons why it is not feasible will be explained.

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a) AFTN line loading

In order to highlight the point, the nature of AFTN links and the monitoring of the AFTN communication line loading are illustrated in the Fig

In the AFTN, the messaging servers are interconnected via a point-to-point line as depicted in Fig. 7. For instance, the AFTN servers A and C, the AFTN servers B and C are interconnected via the Line X and Y respectively, although only one direction of message flow alone the lines is shown in Fig., with Queues. The Queue X indicates the possible delay of messaging from the Server A to C caused by the overloaded communication line X. By monitoring the loading of lines, the messaging between two specific servers can be detected to be inefficient because of the overloaded communication line. In that sense, it is meaningful to monitor the line loadings for knowing the level of messaging demand possibly exceeding the messaging capacity, since the bottleneck of the AFTN messaging is considered as the low line speed unable to handle the messaging demand.
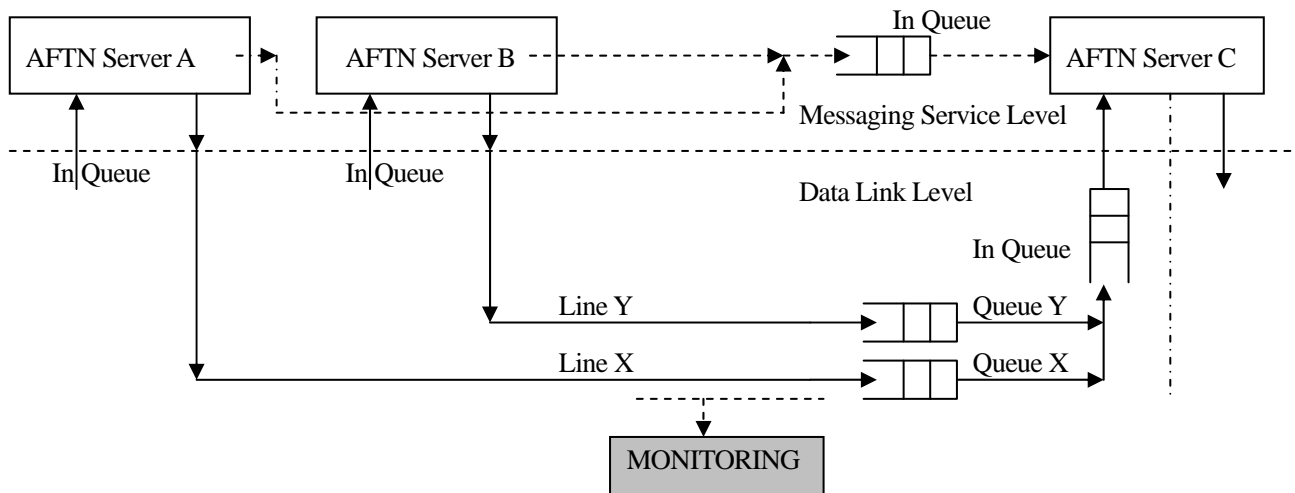


Fig.7 AFTN messaging servers and AFTN lines

It should be noted that
1) the line loading will be dynamic, so that the sampling time has to be selected properly,
2) by merely adding up the monitored traffic over lines, even if all line loadings are monitored at same time, it may not provide the information on transmission time mentioned above, for instance, during the most busiest hour. The information gathered here, line loading, is one of the capacity (or throughput) related measures, rather than the measure of transmission time interval.

b) AMHS and Network Level Performance

In case of the AMHS, similar monitoring, like the AFTN line load monitoring, does not make any sense. In Fig.8, the Router network is shown where the packets are relayed between Routers. The AMHS messages may be routed through better or the best possible paths depending on line loading and other factors. Since the routing is dynamic in nature; packets travel through possibly different paths for same destination, and the packets traveling through a particular line are mixed of different destinations, the monitoring of particular lines can not be related to any messaging performance between two specific AMHS servers. Technically speaking, it is not feasible to evaluate the AMHS messaging services through the Network Level monitoring.

The issue of evaluating performance of the Router Network will be handled as its own, independent to the AMHS messaging services. This is the reason why the document is titled AMHS performance instead of ATN performance, where the ATN includes the Network level, while the AMHS does not.
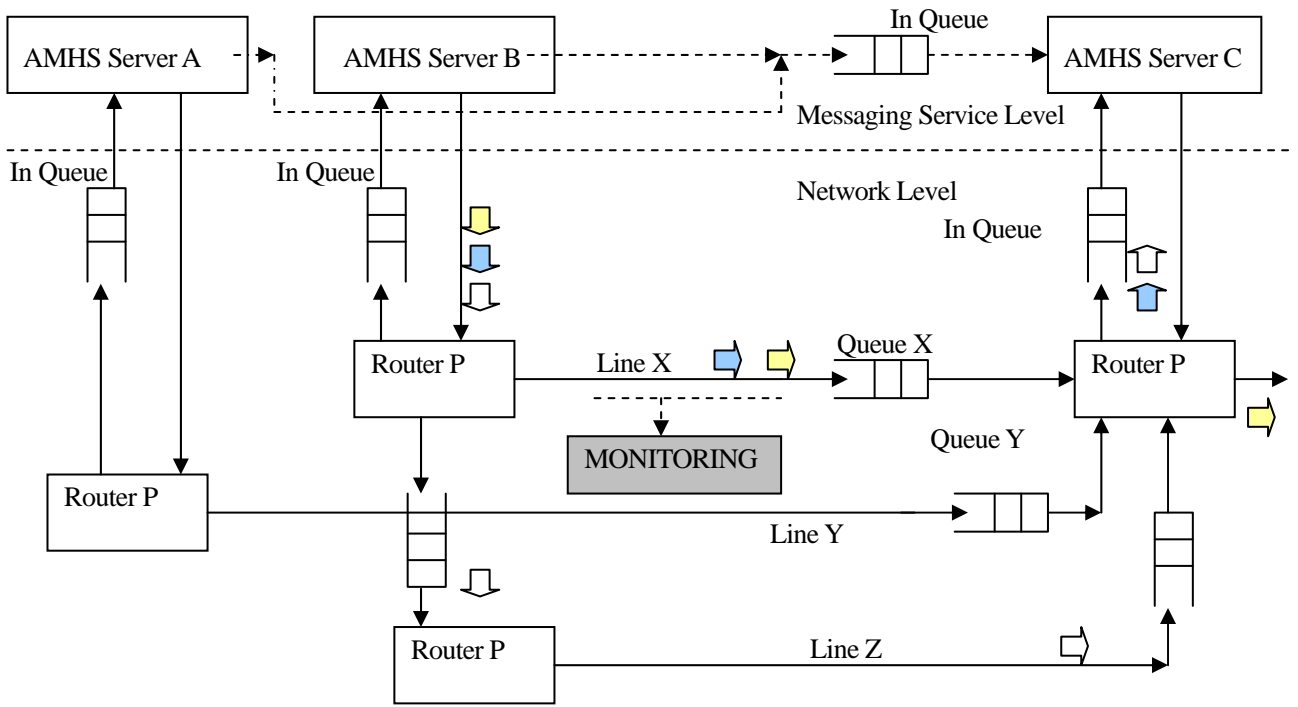
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Fig.8 AMHS messaging servers and Router Network