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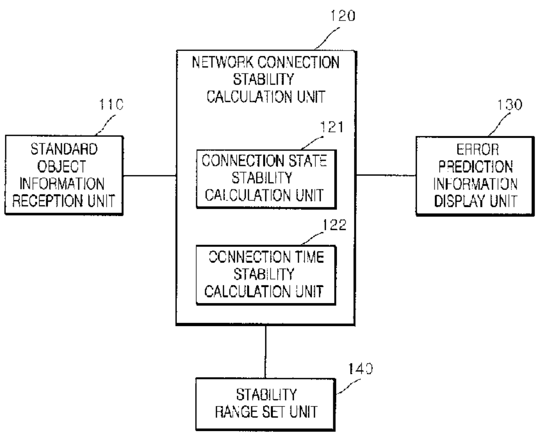
(54) **Titre : DISPOSITIF ET PROCEDE PERMETTANT DE CALCULER LA STABILITE ET DE PREDIRE UNE ERREUR D'UN RESEAU DE SYSTEME ELECTRIQUE**
(54) **Title: DEVICE AND METHOD FOR CALCULATING STABILITY AND PREDICTING ERROR OF POWER SYSTEM NETWORK**



(57) **Abrégé/Abstract:**
The present invention relates to a device and a method for calculating stability and predicting an error of a power system network, the device comprising: a standard object information reception unit for receiving standard object information provided by a power system network; a connection state stability calculation unit for calculating connection state stability (S_{state}) using the standard object information; a connection time stability calculation unit for calculating connection time stability (S_{time}) using the standard object information; a network connection stability calculation unit for calculating a final network connection stability using the network connection state stability (S_{state}) and the connection time stability (S_{time}); and an error prediction information display unit for displaying error prediction information including at least one of network path information, a network state value, the final network connection stability, the connection state stability (S_{state}), and the connection time stability (S_{time}).

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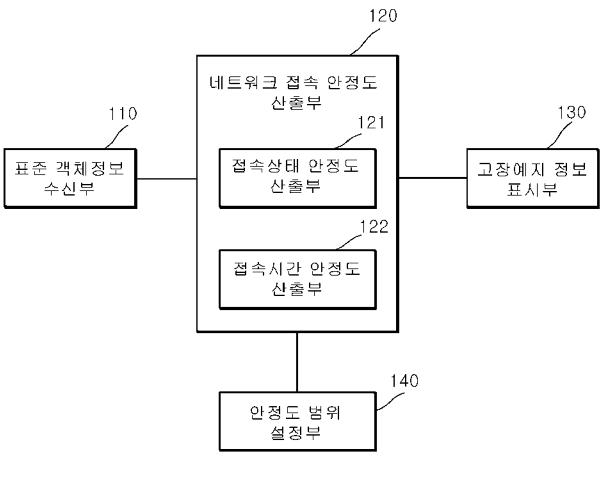
[다음 쪽 계속]

(54) **Title**: DEVICE AND METHOD FOR CALCULATING STABILITY AND PREDICTING ERROR OF POWER SYSTEM NETWORK

(54) **발명의 명칭** : 전력시스템 네트워크의 안정도 산출 및 고장예지 장치와 방법



110 ... Standard object information reception unit
120 ... Network connection stability calculation unit
121 ... Connection state stability calculation unit
122 ... Connection time stability calculation unit
130 ... Error prediction information display unit
140 ... Stability range setting unit

(57) **Abstract**: The present invention relates to a device and a method for calculating stability and predicting an error of a power system network, the device comprising: a standard object information reception unit for receiving standard object information provided by a power system network; a connection state stability calculation unit for calculating connection state stability (S_{state}) using the standard object information; a connection time stability calculation unit for calculating connection time stability (S_{time}) using the standard object information; a network connection stability calculation unit for calculating a final network connection stability using the network connection state stability (S_{state}) and the connection time stability (S_{time}); and an error prediction information display unit for displaying error prediction information including at least one of network path information, a network state value, the final network connection stability, the connection state stability (S_{state}), and the connection time stability (S_{time}).

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공개:

— 국제조사보고서와 함께 (조약 제 21 조(3))

본 발명은 전력시스템 네트워크의 안정도 산출 및 고장예지 장치 및 방법에 관한 것으로, 상기 장치는, 전력시스템 네트워크로부터 제공되는 표준 객체정보를 수신하는 표준 객체정보 수신부, 상기 표준 객체정보를 이용하여 접속상태 안정도(S_{state})를 산출하는 접속상태 안정도 산출부, 상기 표준 객체정보를 이용하여 접속시간 안정도(S_{time})를 산출하는 접속시간 안정도 산출부, 상기 네트워크 접속상태 안정도(S_{state})와 접속시간 안정도(S_{time})를 이용하여 최종 네트워크 접속 안정도를 산출하는 네트워크 접속 안정도 산출부 및 상기 네트워크의 경로 정보, 네트워크의 상태값, 최종 네트워크 접속 안정도, 접속상태 안정도(S_{state}), 및 접속시간 안정도(S_{time}) 중 적어도 하나 이상을 포함하는 고장예지 정보를 표시하는 고장예지 정보 표시부를 포함한다.

DEVICE AND METHOD FOR CALCULATING STABILITY AND PREDICTING ERROR OF POWER SYSTEM NETWORK

Technical Field

The present invention relates to a device and method for calculating stability of a power system network and predicting an error thereof, and more particularly, to a device and method for calculating stability of a power system network and predicting an error thereof, which are capable of calculating stability of the power system network in a formula on the basis of standard object information and predicting an error thereof using the stability.

Background Art

Recently, when key operation information of a substation cannot be exchanged in a power system due to a network problem, an operator's manipulation and determination of an automated device may be interrupted and thus large-scale economic and social damages such as a power failure accident may occur.

Thus, the International Electro-technical Commission (IEC) prescribed a standard (IEC TS(Technical Specification) 62351-7, edition 1.0, "Power systems management and associated information exchange – Data and communications security – Part 7: Network and System Management (NSM) data object models", IEC Standard Committee, 2017-07, IEC standard repository) for network and system management (NSM) information specialized for power systems and provided it to global utilities, thereby contributing to stable operation of power systems.

The NSM information according to the above standard is different from a general IT environment in that a main path and alternative paths of a network, data type, etc. are defined beforehand according to a specific pattern so that an alarm may

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be generated when a network path or data which does not match the specific pattern occurs.

According to the standard (IEC62351-7) for the NSM information specialized for power systems, an object for connection and maintenance of a network is defined as in Table 1 below.

Table 1

Classification	Name of information (object)	Type	Description
Configuration value	ConnRtryCnt	Integer	Number of times to retry to connect to network to change state from temporary error state to permanent error state
	ConnRtryTmms	Time	Time interval between retries of connection in temporary error state
	ConnFailRtryCnt	Integer	Number of times to retry to connect in permanent error state
	ConnFailRtryTmms	Time	Time interval between retries of connection in permanent error state
	NetAltPth	OI Array	List of alternative paths to main path
Operational value	RsTmms	Time	Total time period after reset
	ConnTotTmms	Time	Total connection time after reset
	ConnCurTmms	Time	Current-connection-state maintenance time after connection to network
	ConnAvTmms	Time	Average connection time
	ConnFailTot	Count	Number of errors occurring in normal

Classification	Name of information (object)	Type	Description
			connections state
	ConnRej	Integer	Number of times to reject trying to connect
	AltPthSt	Status	States of alternative paths to main path
Alarm	ConnAlm	Alarm	Alarm for temporary connection error
	ConnFailAlm	Alarm	Alarm for permanent connection error
	ConnFlovAlm	Alarm	Alarm for alternative connection

In Table 1 above, the 'configuration value' represents values designated beforehand for network maintenance, the 'operational value' represents state values generated during actual operation of the network, and the 'alarm' represents important information to be delivered to an operator.

However, information which an operator can intuitively know among the information shown in Table 1 above (standard object information) is only information indicating whether an alarm is generated or not. The information shown in Table 1 above does not include information enabling the operator to determine current stability of a network. That is, only a major problem or an error of the network is reported to the operator and information enabling the operator to predict the problem or error beforehand is not provided to the operator.

For example, the scale of an electric power accident may vary according to an operator's initial response thereto as known in previous electric power accident cases (e.g., the California electricity crisis, the South Korea 915 rolling blackout, etc.). That is, the scale of the electric power accident is significantly influenced by a

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response time of several seconds to several tens of seconds at an initial stage thereof. Thus, if information enabling the operator to predict the electric power accident is provided to the operator before an alarm is generated, the scale of this accident may be dramatically reduced.

However, information directly delivered to an operator among the NSM information according to the standard prescribed by the IEC is only alarm information (i.e., an alarm regarding a network error result), and information enabling the operator to predict a risk of an electric power accident is not provided. Accordingly, the operator cannot notice a state of a network before a network error occurs and thus cannot respond to prevent occurrence and expansion of an accident before the network error occurs (or before an alarm is generated).

The prior art is disclosed in Korean Patent No. 10-0728823, entitled "System and Method for Estimating an Voltage Stability of Power System" (registered on June 8, 2007).

Disclosure

Technical Problem

In order to solve the above problem, the present invention is directed to a device and method for calculating stability of a power system network in a formula on the basis of standard object information and predicting an error thereof using the stability.

Technical Solution

One aspect of the present invention provides a device for calculating stability of a power system network and predicting an error thereof, the device including a standard object information reception unit configured to receive standard object information from a power system network; a connection state stability calculation unit configured to calculate connection state stability S_{state} representing whether a network connection state is stable on the basis of the standard object information; a connection time stability calculation unit configured to calculate connection time stability S_{time} representing whether a network connection time is stably maintained on the basis of the standard object information; a network connection stability calculation unit configured to calculate final network connection stability using the network connection state stability S_{state} and the connection time stability S_{time}; and an error prediction information display unit configured to display error prediction information. The standard object information includes at least one of: a number of times to retry to connect to the network *ConnRtryCnt* until a state is changed from a temporary error state to a permanent error state; a number of times to retry to connect to the network *ConnFailRtryCnt* in the permanent error state; a number of times to reject trying to connect to the network *ConnRej*; a list of alternative paths to a main path *NetAltPth*; states of the alternative paths to the main path *AltPthSt*; and an available valid path *availablePath*. The standard object information includes at least one of: an average connection time *ConnAvTmms*; and a current-connection-state maintenance time *ConnCurTmms* after connection to the network. The error prediction information may include at least one of: the final network connection stability; the connection state stability S_{state}; the connection time stability S_{time}; and network path information and values of states of the network.

In the present invention, the error prediction information display unit may classify and display the final network connection stability in stages including at least one among state changing, a danger, an alarm, and safety, wherein the stages may be displayed using different colors.

In the present invention, the error prediction information display unit may include a route display unit configured to display whether a network connection path is a main path or an alternative path; a network state value display unit configured to display a current state of the network; a final stability display unit configured to display the final network connection stability calculated by assigning weights to the connection state stability S_{state} and the connection time stability S_{time}; a connection state stability display unit configured to display a result of calculating the connection state stability; and a connection time stability display unit configured to display a result of calculating the connection time stability.

In the present invention, the values of the states of the network may include one of: a value of a state representing a start operation of starting connection to the network; a value of a state representing a connection try operation of repeatedly trying connection to the network until connection to the network succeeds; a value of a state representing a connection operation in which connection to the network is made normally and information is exchanged; a value of a state representing a temporary error operation in which a temporary network connection error occurs; a value of a state representing a permanent error operation in which a permanent network connection error occurs; a value of a state representing an alternative connection try operation of trying to connect to the network using an available alternative path when connection to the network through a main path is difficult; a value of a state representing an alternative-path connection operation of connecting to the network through an alternative path rather than the main path; and a value of a state representing an end operation of ending connection to the network.

In the present invention, the start operation may be changed to the connection try operation when a predetermined time period elapses. The connection try operation may be changed to the connection operation when connection to the network succeeds, be changed to the permanent error operation when a number-of-times-to-retry-to-connect information value *ConnRtryCnt* until a state is changed from the temporary error state to the permanent error state is equal to a number-of-times-to-reject-trying-to-connect information value *ConnRej*, and be changed to the alternative connection try operation when a number-of-times-to-retry-to-connect information value *ConnFailRtryCnt* and the number-of-times-to-reject-trying-to-connect information value *ConnRej* are equal to each other in the permanent error state. The connection operation may be changed to the temporary error operation when a temporary connection error generation alarm *ConnAlm* is generated, and be changed to the end operation when data transmission is completed or connection to the network is ended normally. The temporary error operation may be changed to the connection try operation when a predetermined time period *ConnRtryTmms* elapses. The permanent error operation may be changed to the connection try operation when a predetermined time period *ConnFailRtryTmms* elapses. The alternative connection try operation may be changed to the alternative-path connection operation when there is an available alternative path *AltPthSt*, and be changed to the end operation when connection to the network is ended abnormally. The alternative-path connection operation may be changed to the end operation when connection to the network through an alternative path succeeds or connection to the network is ended normally.

In the present invention, the network connection stability calculation unit may calculate the final network connection stability S by adding a product of the connection state stability S_{state} and a predetermined first weight and a product of the connection time stability S_{time} and a predetermined second weight.

In the present invention, the connection state stability calculation unit may calculate the connection state stability S_{state} using a variation in an operational value representing an unstable connection state and a total number of lines through which the network is connectable using an alternative path, wherein the unstable connection state may include the temporary error state or the permanent error state.

In the present invention, the connection time stability calculation unit may calculate the connection time stability S_{time} from a current connection time versus an average connection time.

Another aspect of the present invention provides a method of calculating stability of a power system network and predicting an error thereof, the method including receiving, by a standard object information reception unit, standard object information from a network which is actually operated; calculating, by a connection state stability calculation unit, connection state stability S_{state} representing whether a network connection state is stable on the basis of the standard object information; calculating, by a connection time stability calculation unit, connection time stability S_{time} representing whether a network connection time is stably maintained on the basis of the standard object information; calculating, by a network connection stability calculation unit, final network connection stability using the connection state stability S_{state} and the connection time stability S_{time}; and displaying, by an error prediction information display unit, error prediction information. The standard object information may include at least one of: a number of times to retry to connect to the network *ConnRtryCnt* until a state is changed from a temporary error state to a permanent error state; a number of times to retry to connect to the network *ConnFailRtryCnt* in the permanent error state; a number of times to reject trying to connect to the network *ConnRej*; a list of alternative paths to a main path *NetAltPth*;

states of the alternative paths to the main path *AltPthSt*; and an available valid path *availablePath*. The standard object information may include at least one of: an average connection time *ConnAvTmms*; and a current-connection-state maintenance time *ConnCurTmms* after connection to the network. The error prediction information may include at least one of: the final network connection stability; the connection state stability S_{state}; the connection time stability S_{time}; and network path information and values of states of the network.

In the present invention, the calculating of the connection state stability S_{state} may include, by the connection state stability calculation unit, calculating the connection state stability S_{state} using a variation in an operational value representing an unstable connection state and a total number of lines through which the network is connectable using an alternative path, wherein the unstable connection state may include the temporary error state or the permanent error state.

In the present invention, the calculating of the connection time stability S_{time} may include, by the connection time stability calculation unit, calculating the connection time stability S_{time} from a current connection time versus an average connection time.

In the present invention, the calculating of the final network connection stability may include, by the network connection stability calculation unit, calculating the final network connection stability by adding a product of the connection state stability S_{state} and a predetermined first weight and a product of the connection time stability S_{time} and a predetermined second weight.

Advantageous Effects

According to the present invention, stability of a power system network is calculated in a formula on the basis of standard object information, and an error of the power system network is predicted using the stability. Thus, an operator may notice a state of a network before an error of the network occurs and may thus quickly and exactly respond when the error occurs (or when an alarm is generated), thereby preventing expansion of an accident.

Description of Drawings

FIG. 1 is a diagram schematically illustrating a structure of a device for calculating stability of a power system network and predicting an error thereof, according to an embodiment of the present invention.

FIG. 2 is a diagram illustrating a state change table showing a current state of a network and a change in the state of the network, according to an embodiment of the present invention.

FIG. 3 is a table showing an operation in each state included in the state change table of FIG. 2, an example of a state to which each state may be changed, and state change conditions.

FIG. 4 is a diagram illustrating a method of displaying error prediction information related to the device of FIG. 1.

FIG. 5 is a diagram illustrating ranges of connection state stability and connection time stability according to an embodiment of the present invention.

FIG. 6 is a flowchart of a method of calculating stability of a power system network and predicting an error thereof, according to an embodiment of the present invention.

FIG. 7 is a table showing a method of calculating stability on the basis of a method of calculating stability of a power system network and predicting an error thereof, and a method of making a response according to the stability, according to an embodiment of the present invention.

Best Mode for Carrying out the Invention

Hereinafter, a device and method for calculating stability of a power system network and predicting an error thereof according to an embodiment of the present invention will be described with reference to the accompanying drawings below.

In the drawings, the thicknesses of lines, the sizes of elements, etc. may be exaggerated for clarity and convenience of explanation. The terms used herein are defined in consideration of functions of the present invention and may be changed according to a user or operator's intentions or precedents. Thus, these terms should be defined based on the whole context of the present invention.

Modes of the Invention

FIG. 1 is a diagram schematically illustrating a structure of a device for calculating stability of a power system network and predicting an error thereof, according to an embodiment of the present invention.

As illustrated in FIG. 1, a device for calculating stability of a power system network and predicting an error thereof according to the present embodiment includes a standard object information reception unit 110, a network connection stability calculation unit 120, a connection state stability calculation unit 121, a connection time stability calculation unit 122, an error prediction information display unit 130, and a stability range set unit 140.

The standard objection information reception unit 110 receives information (standard objection information) according to a standard (IEC62351-7) from a predetermined specific power system network.

The network connection stability calculation unit 120 calculates final network connection stability using network connection state stability S_{state} and connection time stability S_{time}.

In the present embodiment, interconnection is assigned to standard object information shown in Table 1 above, and states and a state change table are defined so that an operator of a power system can intuitively know a current network state (see FIG. 2).

FIG. 2 is a diagram illustrating a state change table showing a current state of a network and a change in the state of the network, according to an embodiment of the present invention. FIG. 3 is a table showing an operation in each state included in the state change table of FIG. 2, an example of a state to which each state may be changed, and state change conditions. States of a network and a process of changing the state of the network to another state will be described with reference to FIGS. 2 and 3 below.

As illustrated in FIG. 2, a start operation S101 is an operation of starting connection to a network, and is changed to a connection try operation S102 after a predetermined time period elapses.

In the connection try operation S102, connection to the network is repeatedly tried until the connection to the network succeeds, in which a connection failure information value (e.g., *ConnRej*) is increased by '1' whenever the connection to the network fails. The connection try operation S102 is changed to a connection (or information exchange) operation S103 when the connection to the network succeeds, is changed to a permanent error operation S105 when a number-of-times-to-retry-to-connect information value *ConnRtryCnt* until a state is changed from a temporary error state to a permanent error state is equal to a number-of-times-to-reject-trying-to-connect information value *ConnRej*, and is changed to an alternative connection try operation S106 when a number-of-times-to-retry-to-connect information value *ConnFailRtryCnt* and the number-of-times-to-reject-trying-to-connect information value *ConnRej* are equal to each other in the permanent error state.

In the connection (or information exchange) operation S103, connection to the network is made normally and thus information is exchanged. The connection (or information exchange) operation S103 is changed to a temporary error operation S104 when a temporary connection error generation alarm *ConnAlm* is generated, and is changed to an end operation S108 when data transmission is completed or the connection to the network is ended normally.

In the temporary error operation S104, a temporary network connection error occurs. The temporary error operation S104 is changed to the connection try operation S102 when a predetermined time period *ConnRtryTmms* elapses.

In the permanent error operation S105, a permanent network connection error occurs. The permanent error operation S105 is changed to the connection try operation S102 when a predetermined time period *ConnFailRtryTmms* elapses.

In the alternative connection try operation S106, connection to the network is tried using an available alternative path when it is difficult to connect to the network using a main path. The alternative connection try operation S106 is changed to an alternative-path connection operation S107 when there is an accessible alternative path *AltPthSt*, and is changed to the end operation S108 when connection to the network is ended abnormally.

In the alternative-path connection operation S107, the network is connected using the alternative path rather than the main path. The alternative-path connection operation S107 is changed to the end operation S108 when connection to the network using the alternative path succeeds or when connection to the network is ended normally.

In the end operation S108, a current connection to the network is ended.

In this case, only the temporary connection error generation alarm *ConnAlm* provided in the temporary error operation S104, an alarm *ConnFailAlm* provided in the permanent error operation S105, and an alarm *ConnFlovAlm* provided in the alternative-path connection operation S107 are provided in the IEC standard (IEC62351-7).

However, these alarms are aimed to simply inform an operator of a network error result but are not information through which the operator may notice a state (stability) of the network and deal with an accident beforehand. Thus, in the present embodiment, network connection stability may be digitized and calculated so that an operator may intuitively notice a current state and stability whenever the network is connected.

The network connection stability may be divided largely into connection state stability S_{state} and connection time stability S_{time}. In the present embodiment, the network connection stability calculation unit 120 calculates the final network connection stability S by assigning weights to the connection state stability S_{state} and the connection time stability S_{time}.

For example, the final network connection stability S=connection state stability S_{state}×weight (e.g., 80%)+connection time stability S_{time}×weight (e.g., 20%). Here, the ratio between the weights is variable.

If a proactive response manual is prepared according to the final network connection stability S and an operator masters the proactive response manual to respond to an accident according to the proactive response manual, expansion of the accident may be effectively prevented.

FIG. 3 is a table showing definition of final network connection stability and a response manual according to an embodiment of the present invention. As illustrated in FIG. 3, when final network connection stability S is less than first stability, e.g., 1.5, a network connection state is stable and thus an operator need not make a response.

When the final network connection stability S is greater than or equal to the first stability, e.g., 1.5, and is less than second stability, e.g., 2.5, a network connection state is not in a range of normal state. Thus the operator may check whether connection to a network is retried, check a state of an alternative path, determine the importance of information from the alternative path, and inform a host system of a danger caused when information is lost.

When the final network connection stability S is greater than or equal to the second stability, e.g., 2.5, and is less than third stability, e.g., 3.5, a network connection state is unstable. Thus, the operator should immediately respond for alternative connection, monitor a list of alternative paths and states thereof, and prepare another alternative path and equipment when connection to the network using an alternative path fails.

When the final network connection stability S is greater than the third stability, e.g., 3.5, a network connection state is difficult to be maintained. Thus, the operator may deploy a network backup device and perform path changing. In this case, a response manual according to the stability S is merely an example and is variable.

The connection state stability calculation unit 121 calculates connection state stability S_{state} using the standard object information received by the standard object information reception unit 110.

The connection state stability S_{state} is calculated from a variation in an operational value representing an unstable connection state (e.g., a temporary error, a permanent error, or the like) and a total number of lines through which the network may be connected using an alternative path.

For example, when a connection error occurs, the connection state stability decreases as a number of times to retry to connect to the network versus a predetermined counter *ConnRtryCnt* or *ConnFailRtryCnt* for determining a change in a network state increases. In contrast, the connection state stability increases as the number of available alternative paths *# of AltPthSt.availablePath+1* to a main path increases among the number of a list of alternative paths *# of NetAltPth+1*.

The connection state stability S_{state} may be calculated by Equation 1 below.

Equation 1

$$S_{state}[\%] = \frac{ConnRtryCnt + ConnFailRtryCnt - ConnRej}{ConnRtryCnt + ConnFailRtryCnt} \times \frac{\#\ of\ AltPthSt\text{-}availablePath+1}{\#\ of\ NetAltPth+1}$$

Here, *ConnRtryCnt* represents a number of times to retry to connect to the network until a state is changed from the temporary error state to the permanent error state, *ConnFailRtryCnt* represents a number of times to retry to connect to the network in the permanent error state, *ConnRej* represents a number of times to reject trying to connect to the network, *NetAltPth* represents a list of alternative paths to a main path, *AltPthSt* represents states of the alternative paths to the main path, and *availablePath* represents an available valid path. Furthermore, # represents a total number, and *+1* represents a random value to be added to prevent a result of an arithmetic formula from being zero.

The connection time stability calculation unit 122 calculates connection time stability S_{time} using the standard object information received by the standard object information reception unit 110.

The connection time stability S_{time} is calculated from a current-connection-state maintenance time *ConnCurTmms* versus an average connection time *ConnAvTmms*.

For example, when an error occurs in relation to the connection time stability S_{time} and causes a frequent change between trying to connect to the network and a connection state, a connection time increases and a number of times to retry to connect to the network significantly increases. Thus, when connection to the network is ended abnormally, a connection time decreases. Stability is highest when the connection state stability S_{state} is 100% or less and 100% or more, and decreases as the connection state stability S_{state} increases to be more than 100% or decreases to be less than 100% (see FIG. 5).

The connection time stability S_{time} may be calculated by Equation 2 below.

Equation 2

$$S_{time}[\%]=\frac{ConnCurTmms}{ConnAvTmms}$$

Here, *ConnAvTmms* represents an average connection time, and *ConnCurTmms* represents a current-connection-state maintenance time after connection to the network.

The error prediction information display unit 130 displays network connection stability calculated by the network connection stability calculation unit 120 in stages (e.g., state changing, a danger, an alarm, safety, etc.) so that an operator may intuitively determine the network connection stability (see FIG. 3).

FIG. 4 is a diagram illustrating a method of displaying error prediction information related to the device of FIG. 1.

As illustrated in FIG. 4, when it is assumed that network stability between a random host A and a host B is displayed, the error prediction information display unit 130 includes a route display unit 131, a network state value display unit 132, a final stability display unit 133, a connection state stability display unit 134, and a connection time stability display unit 135.

The route display unit 131 displays whether a current network connection path is a main path (primary path) *P* or an alternative path (second path) *S*. The network state value display unit 132 displays a current state of a network (one of eight states thereof) (see FIG. 2). The final stability display unit 133 displays final network connection stability calculated by assigning weights to connection state stability S_{state} and connection time stability S_{time}. The connection state stability display unit 134 displays a result of calculating the connection state stability S_{state}. The connection time stability display unit 135 calculates a result of calculating the connection time stability S_{time}.

A method of referring to information displayed on the route display unit 131 will be described below.

For example, when a network path is displayed as the alternative path *S* on the route display unit 131, it means that a problem has already occurred once or more. Thus, an operator should carefully monitor a connection state. A state of the network is a most stable state when a value of the state of the network displayed on the network state value display unit 132 represents the connection operation S103, is a state in which an error occurs and which thus needs attention when the value of the state represents the temporary error operation S104 or the permanent error operation S105, and is a state in which connection to the network using the alternative path *S* succeeds and which thus needs to be carefully monitored whether the state is continuously stably maintained when the value of the state represents the alternative-path connection operation S107. The final stability display unit 133 may display final network connection stability, and an operator's response may be thus additionally prepared and operated according to this stability.

Each of the display units 131 to 135 may classify stabilities according to stages (e.g., state changing, a danger, an alarm, safety, etc.), determine specific colors (e.g., red, yellow, white, green, etc.) to correspond to the stabilities, and display the stabilities using the colors. That is, it is possible to help an operator's intuitive determination by assigning the colors to the stages.

The stability range set unit 140 determines ranges of the connection state stability S_{state} and the connection time stability S_{time}. Instability and final network connection stability are calculated on the basis of the determined ranges.

FIG. 5 is a diagram illustrating ranges of connection state stability and connection time stability according to an embodiment of the present invention. As illustrated in FIG. 5, a range of connection state stability S_{state} is determined such that 0% to 25% represents a serious state, 25% to 50% represents a waring state, 50% to 75% represents a caution state, and 75% to 100% represents a normal state.

A range of connection time stability S_{time} is determined such that 0% to 25% represents a serious state, 25% to 50% represents a warning state, 50% to 75%

represents a caution state, 75% to 150% represents a normal state, 150% to 200% represents a caution state, 200% to 400% represents a warning state, and 400% to 800% represents a serious state. In this case, the ranges of the connection state stability S_{state} and the connection time stability S_{time} are merely examples and are thus variable.

FIG. 6 is a flowchart of a method of calculating stability of a power system network and predicting an error thereof, according to an embodiment of the present invention. FIG. 7 is a table showing a method of calculating stability on the basis of a method of calculating stability of a power system network and predicting an error thereof, and a method of making a response according to the stability, according to an embodiment of the present invention.

A method of calculating stability of a network and predicting an error thereof according to the present embodiment will be described with reference to FIGS. 6 and 7 below.

As illustrated in FIG. 6, the standard object information reception unit 110 receives standard object information as shown in the table of FIG. 7 during actual operation of a network (S201). For convenience of explanation, it is assumed that two types of standard object information (e.g., Examples 1 and 2) are received.

The connection state stability calculation unit 121 calculates connection state stability using Equation 1 above on the basis of the standard object information (S202).

For example, as illustrated in FIG. 7, connection state stability calculated using the standard object information input as Example 1 is 75% and thus represents a normal stability state but connection state stability calculated using the standard object information input as Example 2 is 17% and thus represents a serious stability state.

The connection time stability calculation unit 122 calculates connection time stability using Equation 2 above (S203).

For example, as illustrated in FIG. 7, connection time stability calculated using the standard object information input using Example 1 is 86% and thus represents a normal stability state, and connection time stability calculated using the standard object information input using Example 2 is 143% and thus also represents a normal stability state.

Thus, the network connection stability calculation unit 120 calculates final network connection stability S using the connection state stability and the connection time stability (S204).

For example, as illustrated in FIG. 7, final network connection stability S according to Example 1 is 1.0 and thus represents a stable network connection state, and final network connection stability S according to Example 2 is 3.4 and thus represents an unstable network connection state.

The error prediction information display unit 130 displays error prediction information calculated using the standard object information, such as path information R, a network state F, stability S, connection state stability S_{state}, connection time stability S_{time}, etc. (S205).

Compared to the final network connection stability S according to Example 2, the final network connection stability S according to Example 1 represents a normal state, in which information is exchanged in a stable state, two available alternative paths are secured, and connection time stability gradually increases as it changes from a 'caution' state to a 'normal' state. Thus, an operator need not make any response.

In contrast, the final network connection stability S according to Example 2 is in a serious state which is a temporary error state since retrying to connect to the network fails twice and in which no alternative paths are secured, deployment of network backup equipment should be considered, a connection time gradually increases due to frequent errors, and connection time stability is about to be changed to a 'warning' state. Thus, an operator should prepare for an immediate response for alternative connection.

As described above, in the present embodiment, stability of a power system network may be calculated in a formula on the basis of standard object information and an error thereof may be predicted using the stability. Thus, an operator may notice a state of the power system network before a network error occurs, and may thus immediately and exactly respond to an error when the error occurs (or when an alarm is generated), thereby improving accident response capabilities.

Although the present invention has been described above with reference to the embodiments illustrated in the drawings, these embodiments are merely examples and it would be obvious to those of ordinary skill in the art that various changes may be made to these embodiments and these embodiments are to cover all modifications, equivalents, and alternatives falling within the scope of the invention. Accordingly, the scope of the invention should be defined in the appended claims.

CLAIMS

1. A device for calculating stability of a power system network and predicting an error thereof, the device comprising:

a standard object information reception unit configured to receive standard object information from the power system network that is actually operating;

a connection state stability calculation unit configured to calculate connection state stability S_{state} representing whether a power system network connection state is stable based on the standard object information,

wherein the standard object information comprises at least one of:

a number of times to retry to connect to the power system network *ConnRtryCnt* until a state is changed from a temporary error state to a permanent error state;

a number of times to retry to connect to the power system network *ConnFailRtryCnt* in the permanent error state;

a number of times to reject trying to connect to the power system network *ConnRej*;

a list of alternative paths to a main path *NetAltPth*;

states of the alternative paths to the main path *AltPthSt*; and

an available valid path *availablePath*;

a connection time stability calculation unit configured to calculate connection time stability S_{time} representing whether a power system network connection time is stably maintained based on the standard object information,

wherein the standard object information comprises at least one of:

an average connection time *ConnAvTmms*; and a current-connection-state maintenance time *ConnCurTmms* after connection to the power system network;

a power system network connection stability calculation unit configured to calculate final power system network connection stability using the power system network connection state stability S_{state} and the connection time stability S_{time}; and

an error prediction information display unit configured to display error prediction information,

wherein the error prediction information comprises at least one of:

the final power system network connection stability;

the connection state stability S_{state};

the connection time stability S_{time}; and

network path information and values of states of the power system network.

2. The device of claim 1, wherein the error prediction information display unit classifies and displays the final power system network connection stability in stages including at least one among state changing, a danger, an alarm, and safety,

wherein the stages are displayed using different colors.

3. The device of claim 1, wherein the error prediction information display unit comprises:

a route display unit configured to display whether a power system network connection path is a main path or an alternative path;

a power system network state value display unit configured to display a current state of the power system network;

a final stability display unit configured to display the final power system network connection stability calculated by assigning weights to the connection state stability S_{state} and the connection time stability S_{time};

a connection state stability display unit configured to display a result of calculating the connection state stability; and

a connection time stability display unit configured to display a result of calculating the connection time stability.

4. The device of claim 1, wherein the values of the states of the power system network comprises one of:

a value of a state representing a start operation of starting connection to the power system network;

a value of a state representing a connection try operation of repeatedly trying connection to the power system network until connection to the power system network succeeds;

a value of a state representing a connection operation in which connection to the power system network is made normally and information is exchanged;

a value of a state representing a temporary error operation in which a temporary power system network connection error occurs;

a value of a state representing a permanent error operation in which a permanent power system network connection error occurs;

a value of a state representing an alternative connection try operation of trying to connect to the power system network using an available alternative path when connection to the power system network through a main path is difficult;

a value of a state representing an alternative-path connection operation of connecting to the power system network through an alternative path rather than the main path; and

a value of a state representing an end operation of ending connection to the power system network.

5. The device of claim 4, wherein the start operation is changed to the connection try operation when a predetermined time period elapses,

the connection try operation is changed to the connection operation when connection to the power system network succeeds, is changed to the permanent error operation when a number-of-times-to-retry-to-connect information value *ConnRtryCnt* until a state is changed from the temporary error state to the permanent error state is equal to a number-of-times-to-reject-trying-to-connect information value *ConnRej*, and is changed to the alternative connection try operation when a number-of-times-to-retry-to-connect information value *ConnFailRtryCnt* and the number-of-times-to-reject-trying-to-connect information value *ConnRej* are equal to each other in the permanent error state,

the connection operation is changed to the temporary error operation when a temporary connection error generation alarm *ConnAlm* is generated, and is changed to the end operation when data transmission is completed or connection to the power system network is ended normally,

the temporary error operation is changed to the connection try operation when a predetermined time period *ConnRtryTmms* elapses,

the permanent error operation is changed to the connection try operation when a predetermined time period *ConnFailRtryTmms* elapses, the alternative connection try operation is changed to the alternative-path connection operation when there is an available alternative path *AltPthSt*, and is changed to the end operation when connection to the power system network is ended abnormally, and

the alternative-path connection operation is changed to the end operation when connection to the power system network through an alternative path succeeds or connection to the power system network is ended normally.

6. The device of claim 1, wherein the power system network connection stability calculation unit calculates the final power system network connection stability by adding a product of the connection state stability S_{state} and a predetermined first weight and a product of the connection time stability S_{time} and a predetermined second weight.

7. The device of claim 1, wherein the connection state stability calculation unit calculates the connection state stability S_{state} using a variation in an operational value representing an unstable connection state and a total number of lines through which the power system network is connectable using an alternative path, wherein the unstable connection state comprises the temporary error state or the permanent error state.

8. The device of claim 1, wherein the connection time stability calculation unit calculates the connection time stability S_{time} from a current connection time versus an average connection time.

9. A method of calculating stability of a power system network and predicting an error thereof, the method comprising:

receiving, by a standard object information reception unit, standard object information from a power system network which is actually operated;

calculating, by a connection state stability calculation unit, a connection state stability S_{state} representing whether a power system network connection state is stable based on the standard object information,

wherein the standard object information comprises at least one of:

a number of times to retry to connect to the power system network *ConnRtryCnt* until a state is changed from a temporary error state to a permanent error state;

a number of times to retry to connect to the power system network *ConnFailRtryCnt* in the permanent error state;

a number of times to reject trying to connect to the power system network *ConnRej*;

a list of alternative paths to a main path *NetAltPth*;

states of the alternative paths to the main path *AltPthSt*; and

an available valid path *availablePath*;

calculating, by a connection time stability calculation unit, connection time stability S_{time} representing whether a power system network connection time is stably maintained based on the standard object information,

wherein the standard object information comprises at least one of:

an average connection time *ConnAvTmms*; and

a current-connection-state maintenance time *ConnCurTmms* after connection to the power system network;

calculating, by a power system network connection stability calculation unit, final power system network connection stability using the connection state stability S_{state} and the connection time stability S_{time}; and

displaying, by an error prediction information display unit, error prediction information,

wherein the error prediction information comprises at least one of:

the final power system network connection stability;

the connection state stability S_{state};

the connection time stability S_{time}; and

network path information and values of states of the power system network.

10. The method of claim 9, wherein the calculating of the connection state stability S_{state} comprises, by the connection state stability calculation unit, calculating the connection state stability S_{state} using a variation in an operational value representing an unstable connection state and a total number of lines through which the power system network is connectable using an alternative path, wherein the unstable connection state comprises the temporary error state or the permanent error state.

11. The method of claim 9, wherein the calculating of the connection time stability S_{time} comprises, by the connection time stability calculation unit, calculating the connection time stability S_{time} from a current connection time versus an average connection time.

12. The method of claim 9, wherein the calculating of the final power system network connection stability comprises, by the power system network connection stability calculation unit, calculating the final power system network connection stability by adding a product of the connection state stability S_{state} and a predetermined first weight and a product of the connection time stability S_{time} and a predetermined second weight.

FIG. 1

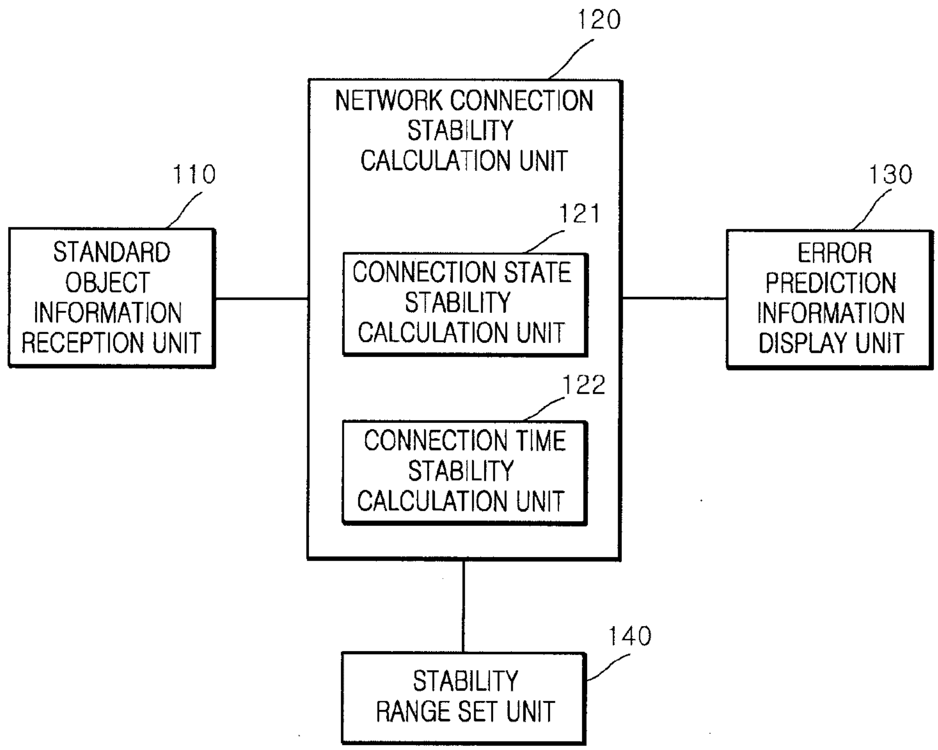

120
NETWORK CONNECTION STABILITY CALCULATION UNIT
121
CONNECTION STATE STABILITY CALCULATION UNIT
122
CONNECTION TIME STABILITY CALCULATION UNIT
110
STANDARD OBJECT INFORMATION RECEPTION UNIT
130
ERROR PREDICTION INFORMATION DISPLAY UNIT
140
STABILITY RANGE SET UNIT

FIG. 2

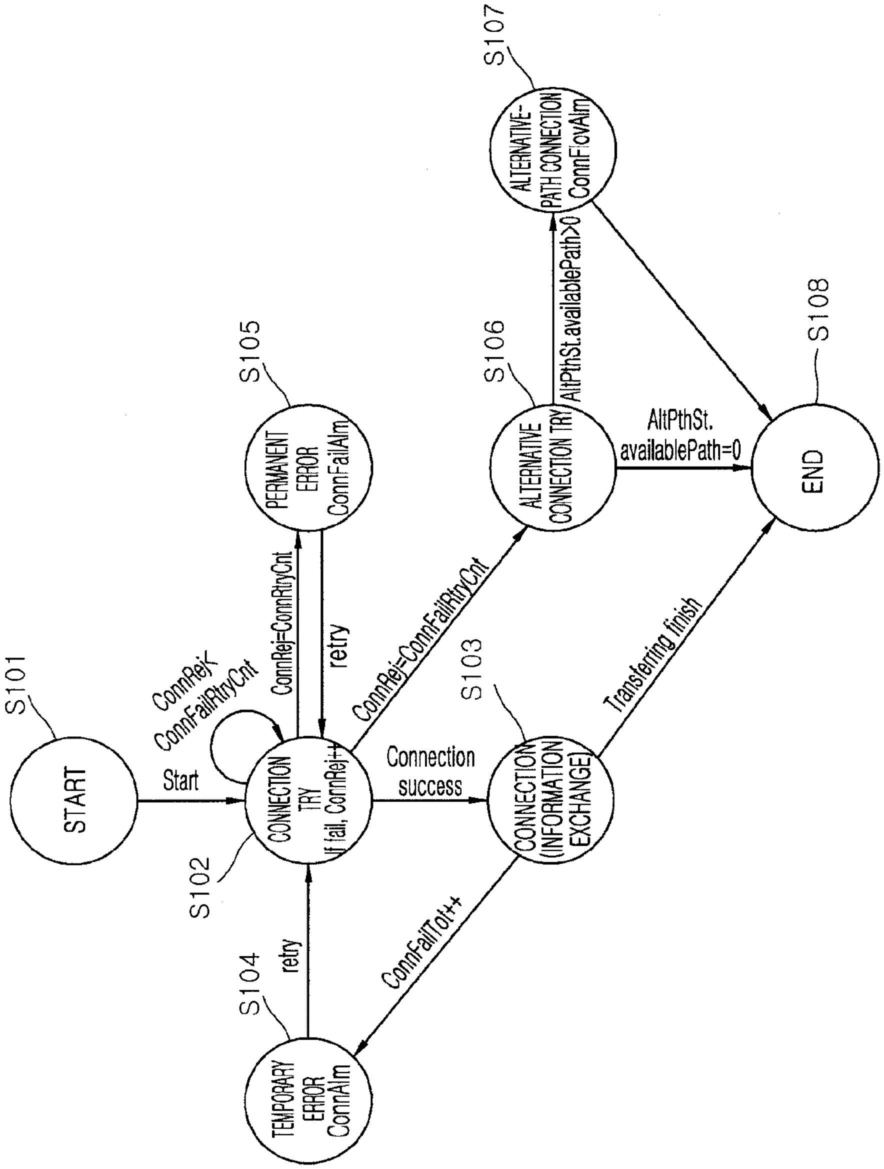

S101
START
Start
S102
CONNECTION TRY If fail, ConnRej++
ConnRej< ConnFailRtryCnt
ConnRej=ConnRtryCnt
retry
S105
PERMANENT ERROR ConnFailAlm
ConnRej=ConnFailRtryCnt
S106
ALTERNATIVE CONNECTION TRY
AltPthSt.availablePath>0
S107
ALTERNATIVE-PATH CONNECTION ConnFlovAlm
AltPthSt. availablePath=0
S108
END
Connection success
S103
CONNECTION (INFORMATION EXCHANGE)
Transferring finish
ConnFailTot++
S104
TEMPORARY ERROR ConnAlm
retry

FIG. 3

RANGE OF STABILITY	DESCRIPTION	RESPONSE MANUAL
$S<1.5$	STABLE NETWORK STATE	NO RESPONSE
$1.5 \leq S<2.5$	NETWORK CONNECTION STATE WHICH IS NOT IN GENERAL STATE	• RETRY TO CONNECT AND CHECK ALTERNATIVE PATH STATE -DETERMINE IMPORTANCE OF INFORMATION FROM CORRESPONDING PATH -INFORM IN ADVANCE HOST SYSTEM OF DANGER CAUSED WHEN INFORMATION IS LOST
$2.5 \leq S<3.5$	UNSTABLE NETWORK CONNECTION STATE	• NEED IMMEDIATE RESPONSE FOR ALTERNATIVE CONNECTION -MONITOR LIST OF ALTERNATIVE PATHS AND STATES THEREOF -PREPARE TO DEPLOY ANOTHER ALTERNATIVE PATH AND EQUIPMENT WHEN ALTERNATIVE-PATH CONNECTION FAILS
$3.5 \leq S$	STATE IN WHICH CONNECTION TO NETWORK IS DIFFICULT TO BE MAINTAINED	DEPLOY BACKUP (NETWORK) EQUIPMENT AND PERFORM PATH CHANGING

FIG. 4

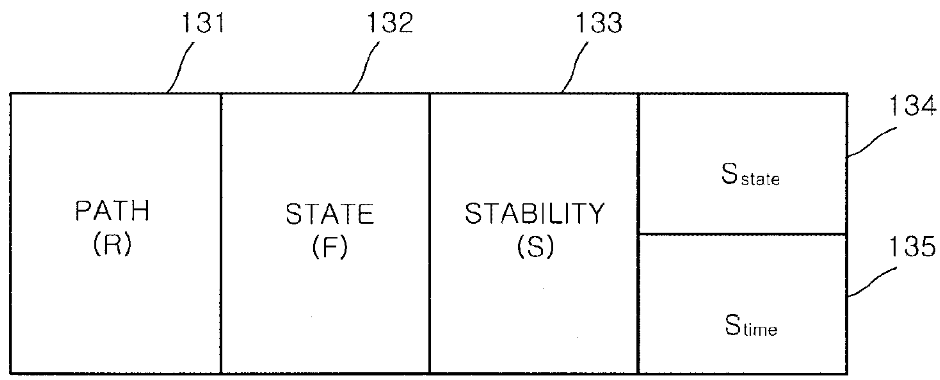


FIG. 5

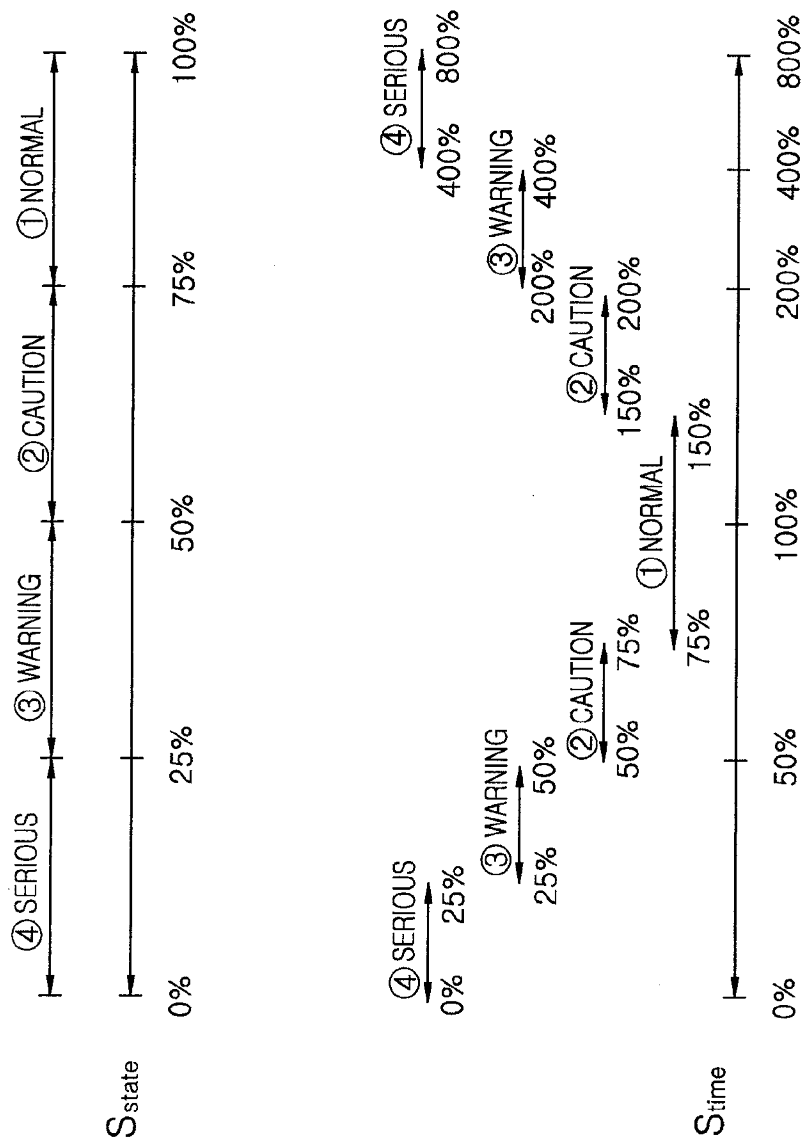

S_state
0%
25%
50%
75%
100%
④ SERIOUS
③ WARNING
② CAUTION
① NORMAL
S_time
0%
50%
100%
200%
400%
800%
④ SERIOUS 0% 25%
③ WARNING 25% 50%
② CAUTION 50% 75%
① NORMAL 75% 150%
② CAUTION 150% 200%
③ WARNING 200% 400%
④ SERIOUS 400% 800%

FIG. 6

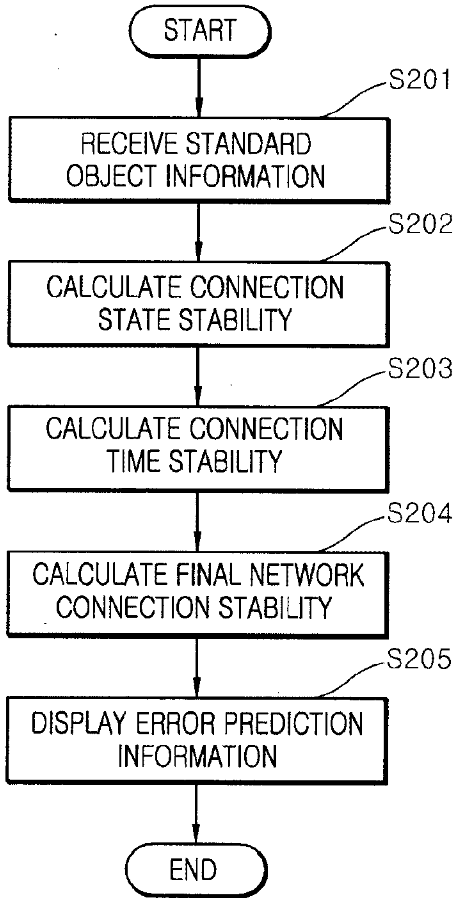
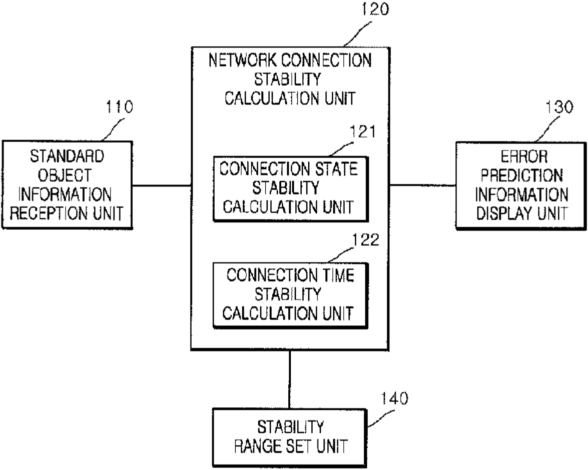

START
S201
RECEIVE STANDARD OBJECT INFORMATION
S202
CALCULATE CONNECTION STATE STABILITY
S203
CALCULATE CONNECTION TIME STABILITY
S204
CALCULATE FINAL NETWORK CONNECTION STABILITY
S205
DISPLAY ERROR PREDICTION INFORMATION
END

FIG. 7

NAME OF INFORMATION	DETAILED INFORMATION		EXAMPLE 1	EXAMPLE 2
STANDARD OBJECT INFORMATION	ConnRtryCnt		3	3
	ConnFailRtryCnt		3	3
	ConnRej		0	2
	# of AltPthSt.Path		2	0
	# of NetAltPth		3	3
	ConnCurTmms		60s	85s
	ConnAvTmms		70s	70s
INVENTION INFORMATION	R	NETWORK PATH		
	F	NETWORK STATE	CONNECTION	TEMPORARY ERROR
	S	STABILITY	1.0	3.4
	S_{state}	CONNECTION STATE STABILITY	75%(1. NORMAL)	17%(4. SERIOUS)
	S_{time}	CONNECTION TIME STABILITY	86%(1. NORMAL)	143%(1. NORMAL)
	OPERATOR'S RESPONSE		NO RESPONSE	IMMEDIATE RESPONSE FOR ALTERNATIVE CONNECTION
ERROR PREDICTION INFORMATION	PATH		PRIMARY	SECOND
	STATE		TEMPORARY ERROR	PERMANENT ERROR
	STABILITY		WARNING	SERIOUS


120
NETWORK CONNECTION STABILITY CALCULATION UNIT
110
STANDARD OBJECT INFORMATION RECEPTION UNIT
121
CONNECTION STATE STABILITY CALCULATION UNIT
122
CONNECTION TIME STABILITY CALCULATION UNIT
130
ERROR PREDICTION INFORMATION DISPLAY UNIT
140
STABILITY RANGE SET UNIT