DESCRIPTION:

The present invention relates to a transmission system for connecting modems which have various common transmission rates, and to means for adapting the transmission rate of these modems to the line quality, comprising first means used during a set-up phase of a communication for:

- exchanging information between the modems relating to their transmission rates,
- providing a measurement of the quality of the transmission medium,
- changing the rate as a function of said measurement.

The invention also relates to a method of adapting the transmission rate to the line quality and to modems implementing said method.

Transmission media are subjected to temporary disturbance (impulse noise, amplitude jumps) or permanent disturbance during the whole connection (white noise), which thus causes frequent resynchronizations or a high error rate to occur. The resynchronizations interrupt the data transmission for several seconds.

There is thus the problem of transmission rate adaptation between two modems (a local modem and a remote modem) as a function of the quality of the line and of the rate capacities of the remote modem. This is described in Japanese Patent Application no. 62-266581 of 23 October 1987, published under number 1-109935. That Application implies that the modems know each other perfectly well.

Currently, modems are proposed which are capable of transmitting data at 7 different rates: from 4800 bits/s to 19200 bits/s in steps of 2400 bits/s, for example. Thus the problem of adaptation to the right rate is much more acute.

The present invention proposes a system which permits connecting modems which have various rates, so that they can mutually adapt their rate.

Therefore, a system of the type described in the opening paragraph is

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synchronization step for defining:

- a minimum exchange rate, rate_min(exchange), so that:

rate_min(exchange) is the greater of the values rate_min(local) and rate_min(remote), where rate_min(local) and rate_min(remote) are the minimum acceptable rates for the local and remote modems, respectively,

- a maximum exchange rate, rate_max(exchange), so that:

rate_max(exchange) is the smaller of the values rate_max(local) and rate_max(remote), where rate_max(local) and rate_max(remote) are the maximum acceptable rates for the local and remote modems, respectively,

third means, used after the synchronization stage, for establishing a rate_trans value which is the transmission rate defined by the quality of the transmission medium.

The following description made with reference to the annexed drawings, all given by way of non-limiting example, will provide a more complete understanding of how the invention can be realised, in which:

Fig. 1 shows a modem according to the invention,

Fig. 2 is a functional block diagram of the modem shown in Fig. 1, and

Fig. 3 shows a system according to the invention having a configuration of two modems according to the invention connected to each other.

The modem shown in Fig. 1 is referenced 1, it interconnects a digital-type terminal 5 and a telephone-type transmission line 7. This modem is constituted based upon microprocessor units 10 and 11. Unit 10 is assigned to the management of the modem and unit 11 is assigned to the signal processor which comprises, habitually, a calculation unit (ALU) 12, a random-access memory 13 and a read-only memory 14 containing the program of instructions which implement the invention. A first interface circuit 15 makes it possible to connect the modem 1 to the terminal 5. A second interface circuit 20 makes it possible to transform on the one hand the signals coming from the telephone line 7 into digital signals and, on the other, to carry out the reverse operation. Such a circuit is described in European Patent Application EP 0 318 105. Unit 11 carries out various functions and, more particularly, transmission channel equalization. This function is illustrated by the functional units shown in Fig. 2.

The signal to be filtered X(t) is received on access 45 coming from line 7

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and is the sum of a payload signal S(t) and line disturbance P(t). The filtered signal Y(t) is compared with a reference signal R(t) by a subtracter element 50. The result is the error signal E(t) which adjusts the coefficients of an equalization filter 55. This filter is characterized by its impulse response H(t,C) which depends on a set of coefficients denoted C. The control of the equalization coefficients is realised by the iterative gradient algorithm *via* error minimization.

The equation to be realised is the following:

$$C_I^{(n+1)} = C_I^{(n)} - \alpha E^{(nT)} - \frac{\delta y^{(nT)}}{\delta C_I^{(n)}}$$

C is a filter coefficient and T is the iteration step. The value of α is important; it is the gain of the equalizer, and determines the duration of the convergence and the value of the residual error.

The error signal E(t) is also used according to the invention for measuring the quality of the transmission medium. The transmission medium is said to be of poor quality if:

- the instantaneous error ratio is higher than a threshold S_{r1},
- the mean error ratio over 5 seconds is higher than a threshold S_{r2}, or
- the mean error ratio over 5 minutes is higher than a threshold S_{r3}.

The transmission medium is said to be of good quality if:

- the instantaneous error ratio is lower than a threshold S_{m1}, and
- the mean error ratio over 5 seconds is lower than a threshold S_{m2}, or
- the mean error ratio over 5 minutes is lower than a threshold S_{m3}.

Each of these thresholds is a constant factor determined as a function of the transmission rate and of the corresponding criterion.

Fig. 3 shows a system with two modems 1 and 80 separated by a transmission medium 85. Modem 1 will be considered the local modem and modem 80 the remote modem. The remote and local modems may have different rates varying in steps of 2400 bits/s. For example, the local modem 1 tolerates rates from 4800 bits/s to 19200 bits/s, whereas the remote modem 80 only tolerates rates from 9600 bits/s to

14400 bits/s. It is thus necessary that the changes of the rates remain compatible with the modems while taking the quality of the transmission medium into consideration.

First of all the following rates will be defined:

rate_min(local):

minimum rate acceptable to the local modem,

rate_max(local):

maximum rate acceptable to the local modem.

These values depend, by composition, on the local modem.

For that matter, there is:

rate_min(remote):

minimum rate acceptable to the remote modem,

rate_max(remote):

maximum rate acceptable to the remote modem.

These values depend, by composition, on the remote modem.

rate_trans: real transmission rate at a given instant,

rate_opt : optimum calculated rate depending on the quality of the line for the direction of transmission from the remote modem to the local modem,

rate_min(exchange): minimum rate common to the two modems,

rate_max(exchange): maximum rate common to the two modems,

a. - Before the connection is switched on, the parameters are initially set as follows:

rate_min(exchange) = rate_min(remote) = rate_min(local)

rate_max(exchange) = rate_max(remote) = rate_max(local)

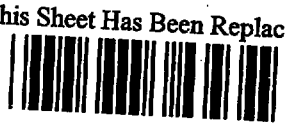
b. - After the connection is switched on (by the signals R1, R2 transmitted at 4800 bits/s, as this is defined by the V32 standard of the CCITT), the local modem knows the tolerances of the remote modem and the remote modem knows the tolerances of the local modem.

Thus one has:

rate_min(exchange) = max{rate_min(local); rate_min(remote)}

rate_max(exchange) = min{rate_max(local); rate_max(remote)}

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rate_trans = 4800 bits/s which is the rate defined by the standard at the start).

The rate may be changed if:

rate_opt ~ rate_trans

The rate can be lowered if the following conditions are met:

rate_opt < rate_trans

rate_min(exchange) < rate_trans

The rate can be raised if the following conditions are met:

rate_opt > rate_trans

rate_max(exchange) > rate_trans

The calculation of the optimum rate does not directly depend on the capacities of the modem. The following holds:

If the quality of the line is considered poor, an optimum rate rate_opt is defined as:

rate_opt = max{rate_trans - rate variation; rate_min(local)}

If the quality of the line is considered good:

rate_opt = min}rate_trans + rate variation; rate_max(local)}

where in practice the rate variation is 2400 bits/s.

The first synchronization of the modems is always effected at the rate_max(exchange). When the rate is lowered, rate_max(exchange) assumes the value of rate_trans. The rising of the rate is thus blocked. To avoid the blocking in the case where the criterion of rate increase has been adhered to for 10 minutes, and if the rate_opt is not higher than rate_max(remote) nor than rate_max(local), the value of rate_max(exchange) becomes:

rate_max(exchange) = rate_opt.

In order that this change of rate can be effected, the synchronization sequence is relaunched and said signals R1 and R2 are used to make this change possible.

Thus, due to the method, the optimum rate calculated by one of the modems is taken into account and is imposed on the remote modem only if the latter is in a position to accept. The advantage of this is that the decision can be made by either of the modems and thus solves the problem of dissymmetrical links.

This makes the procedure highly flexible, but also reliable, because each

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modem is informed of the acceptable rates by the remote modem and will not ask a change of rate untimely.

- Example of use (see Fig. 3)

It will be recollected that modem 1 has the following rate capacities: 19200 bits/s to 4800 bits/s, and modem 80: 14400 bits/s to 9600 bits/s.

The transmission medium between modem 1 towards modem 80 is degraded and then, after several minutes, the quality is restored again.

Here are the resultant changes of the rate:

Modem 1.

rate_max(local) = 19200 bits/s

rate_min(local) = 4800 bits/s

Modem 80.

rate_max(local) = 14400 bits/s

rate_min(local) = 9600 bits/s

STARTING SYNCHRONISATION

Modem 1.

rate_max(remote) = 14400 bits/s

rate_min(remote) = 9600 bits/s

rate_max(exchange) = 14400 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 14400 bits/s

Modem 80.

rate_max(remote) = 19200 bits/s

rate_min(remote) = 4800 bits/s

rate_max(exchange) = 14400 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 14400 bits/s

1 : RATE_OPT = 16800 bits/S

80: RATE_OPT = 12000 bits/S

↓

RATE REDUCTION BY 80

Modem 1.

rate_max(exchange) = 12000 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 12000 bits/s

Modem 80.

rate_max(exchange) = 12000 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 12000 bits/s

1 : RATE_OPT = 14400 bits/s

80: RATE_OPT = 9600 bits/s

↓

RATE REDUCTION BY 80

Modem 1.

rate_max(exchange) = 9600 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 9600 bits/s

Modem 80.

rate_max(exchange) = 9600 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 9600 bits/s

1 : RATE_OPT = 12000 bits/s

80 : RATE_OPT = 7200 bits/s

↓

NO CHANGE OF RATE

THE QUALITY OF THE LINE BECOMES GOOD AGAIN

Modem 1.

rate_max(exchange) = 9600 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 9600 bits/s

Modem 80.

rate_max(exchange) = 9600 bits/s

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rate_min(exchange) = 9600 bits/s

rate_trans = 9600 bits/s

1 : RATE_OPT = 12000 bits/s

80 : RATE_OPT = 12000 bits/s

↓

MONITORING OF THE RATE RATE_OPT (*)

FOR 10 MINUTES

↓

1 : RATE_OPT = 12000 bits/s

80 : RATE_OPT = 12000 bits/s

↓

RATE RAISED BY 1

Modem 1.

rate_max(exchange) = 12000 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 12000 bits/s

Modem 80.

rate_max(exchange) = 12000 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 12000 bits/s

1 : RATE_OPT = 14400 bits/s

80 : RATE_OPT = 14400 bits/s

↓

MONITORING OF THE RATE RATE_OPT (*)

FOR 10 MINUTES

↓

1 : RATE_OPT = 14400 bits/s

80 : RATE_OPT = 14400 bits/s

↓

RATE RAISED BY 1 OR 80

Modem 1.

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rate_max(exchange) = 14400 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 14400 bits/s

Modem 80.

rate_max(exchange) = 14400 bits/s

rate_min(exchange) = 9600 bits/s

rate_trans = 14400 bits/s

1 : RATE_OPT = 16800 bits/s

80 : RATE_OPT = 16800 bits/s

↓

NO CHANGE OF RATE

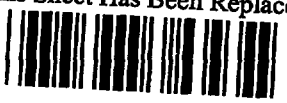
It will be noted that to avoid an incessant weighing between two adjacent rates, the lowering and rising thresholds are defined for each criterion with a hysteresis of 0.1 between the two thresholds (*i.e.* about 3 dB).

(* the error ratio is satisfactory for this duration and a rise of the rate is considered).

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CLAIMS:

1. Transmission system for connecting modems which have various common transmission rates, and to means for adapting the transmission rate of these modems to the line quality, comprising first means used during a set-up phase of a communication for:

- exchanging information between the modems relating to their transmission rates,
- providing a measurement of the quality of the transmission medium,
- changing the rate as a function of said measurement, which system is characterized in that, for connecting a local modem to a remote modem which implies a synchronization phase, it further comprises second means used prior to the whole synchronization step for defining:
- a minimum exchange rate, rate_min(exchange), so that:

  rate_min(exchange) is the greater of the values rate_min(local) and rate_min(remote), where rate_min(local) and rate_min(remote) are the minimum acceptable rates for the local and remote modems, respectively,
- a maximum exchange rate, rate_max(exchange), so that:

  rate_max(exchange) is the smaller of the values rate_max(local) and rate_max(remote), where rate_max(local) and rate_max(remote) are the maximum acceptable rates for the local and remote modems, respectively,

third means, used after the synchronization stage, for establishing a rate_trans value which is the transmission rate defined by the quality of the transmission medium.

2. System as claimed in Claim 1 for which certain modems of its modems satisfy the V32 standards of the CCITT, characterized in that for these modems the information signals changed are the signal R1, R2 of said standards.

3. System as claimed in Claim 1 or 2, characterized in that the quality is measured *via* the error signal controlling the echo cancellers.

4. System as claimed in one of the Claims 1 to 3, characterized in that it



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comprises rate changing means conditioned by the fact that the value rate_opt ~ lies near the rate_trans, where rate_opt is the optimum rate determined on the basis of the line quality for the direction of transmission from the remote modem to the local modem, rate_opt having the value of rate_trans plus or minus rate variation, where rate variation is a variation of the rate tolerated by the modem, changing means for changing the rate being provided for effecting a lowering of the rate if rate_opt is lower than rate_trans and rate_min(exchange) is lower than rate_trans, and provided for raising the rate if rate_opt is higher than rate_trans and rate_max(exchange) is higher than rate_trans.

5. Method of connecting the modems which have various common rates and of adapting the transmission rate to the line quality, comprising the following stagesutilized during a set-up phase of a communication:

- exchange of information relating to the rates between the modems,
- measurement of the quality of the transmission medium,
- change of the rate as a function of said measurement,

which method implies a synchronization phase for connecting a local modem with a remote modem, characterized in that before the synchronization stage there is defined:

- a minimum exchange rate rate_min(exchange), so that: rate_min(exchange) is the greater of the values rate_min(local) and rate_min(remote), where rate_min(local) and rate_min(remote) are the minimum acceptable rates for the local and remote modems, respectively,
- a maximum exchange rate rate_max(exchange), so that: $rate_{_max}$(exchange) is the smaller of the values rate_max(local) and rate_max(remote), where rate_max(local) and rate_max(remote) are the maximum acceptable rates for the local and remote modems, respectively,

and in that after the synchronization stage the rate_trans is established being thus the transmission rate defined by the quality of the transmission medium.

6. Method as claimed in Claim 5 for which the modems satisfy the V32 standard of CCITT, characterized in that the information signals exchanged are the signals R1, R2 of said standards.

7. Method as claimed in Claim 5 or 6, characterized in that the measurement of the quality is carried out on the error signal which controls the echo cancellers.

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8. Method as claimed in one of the Claims 4 to 7, characterized in that the change of rate is conditioned by the fact that the value rate_opt ~ lies close to rate_trans, where rate_opt is the optimum rate determined on the basis of the line quality for the direction of transmission from the remote modem to the local modem, rate_opt having the value of rate_trans plus or minus rate variation, where rate variation is a variation of the rate tolerated by the modem, rate changing means being provided for effecting a lowering of the rate if rate_opt is lower than rate_trans and rate_min(exchange) is lower than rate_trans, and provided for raising the rate if rate_opt is higher than rate_trans and rate_max(exchange) is higher than rate_trans.

9. Modem comprising first means used during a set-up phase of a communication for:

- exchanging information between this modem and a remote modem relating to their transmission rates,
- providing a measurement of the quality of the transmission medium,
- changing the rate as a function of said measurement, characterized in that, for connecting this modem to a remote modem which implies a synchronization phase, it further comprises second means used prior to the whole synchronization step for defining:
- a minimum exchange rate, rate_min(exchange), so that:

  rate_min(exchange) is the greater of the values rate_min(local) and rate_min(remote), where rate_min(local) and rate_min(remote) are the minimum acceptable rates for the local and remote modems, respectively,
- a maximum exchange rate, rate_max(exchange), so that:

  rate_max(exchange) is the smaller of the values rate_max(local) and rate_max(remote), where rate_max(local) and rate_max(remote) are the maximum acceptable rates for the local and remote modems, respectively,

third means, used after the synchronization stage, for establishing a rate_trans value which is the transmission rate defined by the quality of the transmission medium.

