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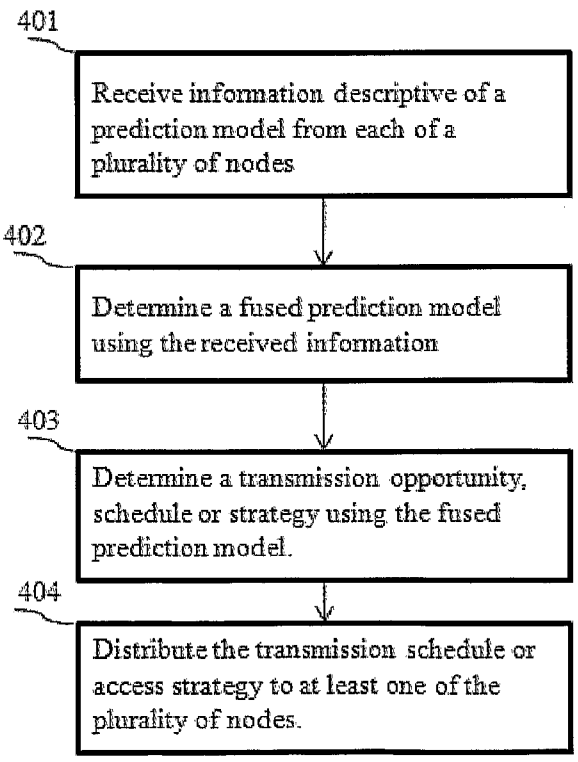


FIGURE 4

(57) Abstract: In accordance with an example embodiment of the present invention, receiving at a first communication node first information descriptive of a first prediction model from a second communication node and determining at the first communication node a second prediction model based at least in part on said first information.

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METHOD AND APPARATUS FOR TRANSFER AND USAGE OF INFORMATION DESCRIPTIVE OF PREDICTION MODELS

TECHNICAL FIELD

The present application relates generally to the transfer and usage of information descriptive of prediction models.

BACKGROUND

As part of normal operation, a node intent on transmitting coordinates the usage of transmission resources with other nodes. According to some protocols, this may be achieved by having one node distribute the transmission resources among competing nodes according to a usage schedule. According to other protocols, this may be achieved by establishing mutual agreement among nodes on the usage schedule. According to yet other protocols, this may be achieved by pseudo-randomly attempting to use transmission resources.

Some of the aforementioned protocols may make use of information obtained from measuring a transmission medium, for example instantaneous availability of resources with the aim of immediate transmission or for another example for statistical availability of resources with the aim of predicting the availability of transmission resources on the measured transmission medium. Some of the aforementioned protocols may also make use of specific information received from other nodes, such as requests or indications of resource usage or predictions on the future state of the transmission medium.

SUMMARY

Various aspects of examples of the invention are set out in the claims. According to a first aspect of the present invention, an apparatus is provided comprising at least one processor and at least one memory including computer program code. The at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to perform at least the following: receiving first information descriptive of a first prediction model from a communication node; and determining a second prediction model using said first information.

According to a second aspect of the present invention, a method is provided, comprising receiving at a first communication node first information descriptive of a first prediction model from a second communication node; and determining at the first communication node a second prediction model based at least in part on said first information.

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BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of example embodiments of the present invention, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

FIGURE 1 illustrates example wireless systems;

FIGURE 2 illustrates an example flow diagram showing operations for receiving information descriptive of a prediction model and determining a second prediction model from the received information;

FIGURE 3 illustrates an example flow diagram showing operations for fusing received information descriptive of prediction models to determine a second prediction model;

FIGURE 4 illustrates an example flow diagram showing operations for fusing received information descriptive of prediction models to determine a second prediction model;

FIGURES 5A, 5B and 5C illustrate several alternative flow diagrams for determining a transmission opportunity, schedule or strategy at a receiver;

FIGURE 6 illustrates an example wireless apparatus in accordance with an example embodiment of the invention; and

FIGURE 7 illustrates an example flow diagram showing operations for determining and using a prediction model.

DETAILED DESCRIPTON

An example embodiment of the present invention and its potential advantages are understood by referring to FIGURES 1 through 7 of the drawings.

FIGURE 1 illustrates example wireless systems 100 and 110. In a master-slave configuration 100, node 101 may be a base station, an access point, a mobile station or a communication terminal acting as master for a cluster of nodes comprising for example nodes 102 and 103. Nodes 102 and 103 may be a mobile station or a communication terminal.

In a peer-to-peer configuration 110, node 111 may be a communication terminal communicating with peer nodes 112 and 113. Nodes 112 and 113 may be a base station, an access point, a mobile station or a communication terminal.

In an example embodiment, node 101 may receive information descriptive of a prediction model from at least one of nodes 102 and 103 over a slave-to-master link. In another example embodiment, node 111 may receive information descriptive of a prediction model from at least one of nodes 112 and 113 over a peer-to-peer link. Such information may be transmitted by any of nodes 102,103 or nodes 112, 113 respectively, for example in the form of a unicast, multicast or broadcast message.

In an example embodiment, information descriptive of a prediction model comprises information describing the composition of the prediction model itself, rather than an output of the prediction model. The information descriptive of a prediction model could for example comprise a prediction model parameter, a prediction model indicator, a prediction model flow description, a prediction model prototype state, a prediction model state transition requirement and/or a prediction model state transition information.

A prediction model parameter may describe a transition probability between different states of the prediction model. Prediction model parameters may be encoded as a matrix of transition probabilities. A prediction model indicator may be for example, a selector between a set of pre-defined prediction models available to the receiver. A prediction model indicator may also comprise an indication to alter an existing model in a predefined manner. A prediction model flow descriptor may be information on when or how often parameter values are to be refreshed or updated, or in what sequence parameter updates, measurements and actions are performed. A prediction model prototype state may for example be a variable that indicates that a model currently assumes a particular situation, such as a particular traffic type, such as for example VoIP or file transfer, and uses predictions designed for such traffic. A prediction model state transition information may indicate the probability that a prediction model remains in a current prototype state, or transfers to another one. Prediction model state transition information may comprise constraints on transitions such as minimal or maximal allowed values for transition probabilities between states.

In either configuration, such information may be transmitted by at least one of nodes 102 and 103 and/or nodes 112 and 113 respectively in a periodic fashion. In an alternative embodiment, such information may be transmitted when the sending node, for example nodes 102, 103, 112 or 113 or the receiving node, for example nodes 101, 111 determine to update the information descriptive of a prediction model. For example, when the sending node updates its own prediction model or when the receiving node detects discrepancies between a sending node's transmission resource usage and the usage predicted from the information descriptive of a prediction model received from that node. Alternatively, the sending node may transmit such information when the receiving node arrives within communication distance of the sending node, which may occur for example due to the receiving node being switched on, rebooted or physically moved.

For the receiving node 101, 111, receiving the information descriptive of a prediction model when entering the transmission range of another node or nodes, for example nodes 102, 103, 112 or 113, is particularly advantageous, as it allows the receiving node to initialize or update its own prediction model using the information obtained from another node or nodes already present in the environment. This reduces and may allow to entirely avoid the possibly

lengthy transmission medium measurements and associated power consumption associated with initializing a prediction model independently.

The transfer of information descriptive of a prediction model, rather than a current settings, historic information, current measurements or an output of a prediction model, such as the next planned transmission time, a transmission power to be used or an antenna configuration to be used, allows the receiver to compute the impact of the sending node's prediction model on its own predictions for as long as the received information descriptive of the sending node's prediction model is accurate. This allows for a reduction in the frequency with which such control information is transferred. Alternatively, the sending of information descriptive of a prediction model at a similar frequency may result in the transfer of substantially less control data when compared to sending the time-variant output of the prediction model. The latter may occur, for example, when the prediction model, while relatively compact in construction, produces one or more output signals the description of which is highly complex.

The transfer of information descriptive of a prediction model according to an aspect of the current invention may also be advantageous to the node sending the information, as it allows the receiving node to effect a more harmonious sharing of the transmission resources with the sending node. This may result in higher spectral efficiency and less transmission collisions.

Any node could act as both sender and receiver of information descriptive of a prediction model, so that all nodes could take equal advantage of such information with the transfer of such information. For example, in the peer-to-peer configuration 110, each node could broadcast information descriptive of its prediction model and consequently receive such information from each of its neighbor nodes.

FIGURE 2 illustrates an example flow diagram showing operations for receiving information descriptive of a prediction model and determining a second prediction model from the received information.

At block 201, a node, for example node 111 of FIGURE 1, receives information descriptive of a prediction model from another node, for example node 112 of FIGURE 1.

At block 202, node 111 determines a second prediction model, for example its own prediction model, based at least in part on the received information. The receiving node may for example determine its own prediction model by initializing or updating its own prediction model based at least in part on the received information. In an embodiment, the receiving node 111 may initialize its own prediction model as a duplicate of the prediction model described by the information, effectively assuming that the model is equally valid for both nodes. Alternatively, node 111 may for example use the information to initiate or update a model of a different type or scope using only part or all of the received information. The latter may for example occur when nodes 111 and 112 are dissimilar in capabilities, e.g. a node may not have adequate computational

resources to process prediction models of a certain complexity, or simply because different vendors of such nodes prefer usage of different prediction models.

If for example the information describes an indication of a set of state transition requirements for a given prediction model structure, the receiving node 111 could copy the set of state transition requirements according to the received information into its own prediction model having the same prediction model structure to initialize its own prediction model. Alternatively, the receiving node could update its own prediction model by adjusting existing state transition requirements of its own prediction model incrementally in the direction of the state transition requirements according to the received information. If a state transition requirement takes the form of a threshold, such an adjustment could for example take the form of $\alpha_{updated\ value} = (1-\mu) * \alpha_{existing\ value} + \mu * \beta$, where α is the threshold describing a state transition requirement of the prediction model of the receiver, β is the threshold describing a state transition requirement per the received information and μ is a constant smaller than 1 to control a rate of the adjustment.

At block 203, the node 111 determines a transmission opportunity, schedule or strategy based at least in part on its own prediction model. The transmission opportunity may be, for example, a time period, frequency band, time/frequency slot, code channel or other type of transmission resource quantity that is predicted to be suitable for a transmission. For example, a transmission opportunity may be determined at a time/frequency slot of a size required for a certain transmission that is predicted not to be used by other nodes according to node 111's own prediction model or predicted to contain acceptable levels of interference due to transmissions by other nodes. In an example embodiment, a transmission schedule comprises a plurality of transmission opportunities, either for a single node, or for a plurality of nodes. A transmission strategy does not comprise transmission opportunities, but less rigid transmission instructions. In an example embodiment, a transmission strategy, for example comprises a plurality of rules or a description of a stochastic finite state controller to be used by at least one node to improve its co-existence behavior. The rules may for example comprise backoff parameters to be used when a collision is detected, channels to prioritize or avoid when seeking a transmission opportunity, etc.

FIGURE 3 illustrates an example flow diagram showing operations for fusing received information descriptive of prediction models to determine a second prediction model. At block 301, a node, for example node 101 of FIGURE 1, receives information descriptive of a prediction model from a plurality of other nodes, for example nodes 102 and 103 of FIGURE 1.

At block 302, node 101 uses the information to determine its own prediction model based at least in part on the received information. Fusion comprises the combination of at least part of information descriptive of a plurality of prediction models into a joint prediction model. In an example embodiment, node 101 fuses the information into a single prediction model. Node 101

may for example construct the fused prediction model comprising the union of a plurality of prediction models as described by the information. In an alternative embodiment, the fused prediction model may be determined from the information using an expectation maximization type algorithm. In yet another embodiment, the fused prediction model may be determined using Gaussian Process based model fusion. Node 101 may also fuse its own existing prediction model with the received information into an updated prediction model. Node 101 may for example determine its own prediction model by initializing or updating its own prediction model with the fused prediction model. In an alternative embodiment, node 101 may determine a plurality of prediction models from the received information and fuse the output of the prediction models in order to establish a joint output.

Node 101 may, similarly to block 203, proceed at block 303 to determine a transmission opportunity, schedule or strategy from the output of the fused prediction model or the fused outputs of the prediction models.

A node may for example create its own prediction model by fusing information from nodes transmitting dissimilar information of the same prediction model such as information describing the transmission resource prediction model of the same shared channel. This information could for example be different from different nodes because of different ways of measurement or because the nodes have a different set of neighbor nodes as a result of signal propagation effects. Because of such signal propagation effects, in one embodiment, the information descriptive of a prediction model would only be shared with the immediate neighbors. Such an embodiment would advantageously improve coexistence with the immediate neighbors at modest complexity, but may ignore certain coexistence considerations with nodes other than the immediate neighbors. This may happen for example when the information descriptive of a prediction model received comprises only information relating to a data source model of the node transmitting the information.

In an alternate embodiment where the receiving node has more computational power available for prediction modeling, the information descriptive of a prediction model could also be shared, for example through forwarding, by nodes beyond the immediate neighbors. Such information may for example enable the receiving node to predict interference levels where all of the immediate neighbors report transmission resources to be available for the receiving node to transmit, for example allowing a more accurate prediction of feasible transmission power and rate to be used during the transmission opportunity.

Alternatively, a node may for example create its own prediction model by fusing information from nodes transmitting information descriptive of different or independent prediction models. This information could for example be descriptive of the source data prediction model of the transmitting node, which is naturally different and largely independent for each node.

FIGURE 4 illustrates an example flow diagram showing operations for fusing received information descriptive of prediction models to determine a second prediction model. At block 401, a node, for example node 101 of FIGURE 1, receives information descriptive of a prediction model from a plurality of other nodes. At block 402, node 101 uses the information to initialize or update its own prediction model by fusing the information into a single prediction model. In an alternative embodiment, the node may establish a plurality of prediction models from the received information and fuse the output of the prediction models in order to establish a joint output.

The node may proceed, similarly to block 203, at block 403 to determine a transmission opportunity, schedule or strategy from the output of the fused prediction model or the fused outputs of the prediction models respectively. In an example embodiment, the transmission schedule comprises an allocation of transmission resources for at least two nodes, for example node 102 and 103.

At block 404, node 101 distributes the determined transmission opportunity, schedule or strategy to at least one node, for example one of the plurality of nodes from which the information was received. In an alternative embodiment, the node may also distribute information descriptive of the fused prediction model itself rather than a transmission opportunity, schedule or strategy determined from it. Distribution of the information descriptive of the fused prediction model, the transmission opportunity, schedule or strategy may for example be performed through a transmission in the form of a unicast, multicast or broadcast message.

In accordance with one embodiment of the invention the determined transmission schedule may vary in detail according to a level of accuracy of the prediction model. For example, when the model is initially relatively inaccurate, the master node could merely distribute the transmissions of the nodes over different available channels or subchannels. When the model becomes accurate over time, the transmission schedule may provide more detailed transmission allocations such as specific time-frequency slots. Furthermore, part of the transmission schedule could be transfer or handover instructions to one or more of the nodes, comprising instructions to transfer or handover to another network or other master node. Such instructions could for example be provided when the prediction model indicates that such nodes would likely not be adequately serviced at a future point in time. In another embodiment, when the model is initially relatively inaccurate, the master node could distribute only a strategy, but switch to transmitting a transmission schedule when the model becomes more accurate over time. In yet another embodiment, the master node could switch back from transmitting a transmission schedule to transmitting a strategy when it is determined that the accuracy of the prediction model has deteriorated. As such, the master node may adapt the transmission schedule detail or adapt the transmission of a transmission schedule or strategy according to the perceived accuracy of the prediction model.

FIGURES 5A, 5B and 5C illustrate several alternative flow diagrams for determining a transmission opportunity, schedule or strategy at a node receiving information descriptive of a prediction model.

FIGURE 5A illustrates an example flow diagram in which at block 501, a node, for example node 111 of FIGURE 1, receives at least one information descriptive of a source data prediction model and determines one or a plurality of source data prediction models from the information. At block 503, node 111 determines a transmission medium prediction model, which may be determined from reception of information thereof from another node or nodes, for example nodes 112 and/or 113 of FIGURE 1, or may be obtained from direct measurement of the transmission medium. At block 502, node 111 constructs a transmission resource prediction model from the at least one source data prediction model 501 and the at least one transmission medium prediction model 503. At block 504, node 111 determines a transmission opportunity, schedule or strategy derived from the transmission resource prediction model.

In accordance with an embodiment of the invention, node 111 determines the transmission resource prediction model 502 by fusing the at least one source data prediction model with at least one transmission medium prediction model 503, determining a transmission opportunity, schedule or strategy 504 from the determined transmission resource prediction model 502. The transmission resource prediction model alternatively may be constructed directly from the received information descriptive of the at least one source data prediction model 501 and the at least one transmission medium prediction model 503 or information descriptive thereof.

As the information descriptive of a source data prediction model potentially has a substantially longer validity duration than the validity duration of a transmission medium prediction model or a transmission resource prediction model, the frequency and volume of information from the nodes transmitting such information may be further reduced.

In an example embodiment, a transmission resource prediction model comprises a model predicting to what extent a transmission resource is available for a transmission by a given node or nodes. Such a model may predict in a Boolean fashion whether a transmission resource is available or not, but may also predict a level of interference to be expected on that transmission resource.

In an example embodiment, a transmission medium prediction model comprises a model predicting the channel quality of transmission links. In an example embodiment, a data source prediction model comprises a model predicting a data flow to and/or from a node, types of data, e.g. video or best effort, requirements such as delay, jitter and rate tolerances etc.

A transmission resource prediction model or a data source prediction model may for example be composed as a Markov model or a Hidden Markov model or a neural network and can for example be of a simulation, dynamic, statistical or heuristic nature. For example, a master

node may use a Partially Observable Markov Decision Process to determine a transmission schedule where the transmission resource prediction model is of a Hidden Markov type.

The information descriptive of a prediction model may comprise for example the transmission resource occupancy predicted by the transmitter for itself or the aggregate transmission resource occupancy predicted by the transmitter for a set of transmitters sharing the resources. Such information may also reflect a subset of known transmission resource occupancy, for example merely predicting the resource occupancy by primary users that secondary users must avoid. Such information may for example be information descriptive of a prediction model describing the sweep of a primary radar. Construction of a prediction model descriptive of primary user transmission resource by a node, the reception of information of which advantageously achieved by a second node according to an embodiment of the present invention, is for example described in "Latent state models of primary user behavior for opportunistic spectrum access" Pajarinen et. al, IEEE Personal Indoor Mobile Radio Conference (PIMRC), Sept. 14-16, 2009, the disclosure of which is incorporated in its entirety by reference.

FIGURE 5B illustrates an example flow diagram in which at block 511, a node, for example node 101 of FIGURE 1, receives at least one information descriptive of a source data prediction model and determines one or a plurality of source data prediction models from the information. At block 515, node 101 obtains a transmission medium status, which may be determined from reception of information thereof from another node or nodes or may be obtained from direct measurement of the transmission medium. A transmission medium status differs from a transmission medium prediction model in that a status represents one or more fixed values, whereas a prediction model comprises a dynamic function. Information of the transmission medium status 515 may be obtained for example from channel quality feedback received from another node or nodes. Or it may for example be determined from arbitrary transmissions from the another node of nodes under an assumption of reciprocity of the transmission channel.

At block 514, node 101 determines a transmission opportunity, schedule or strategy derived from the source data prediction model and the transmission medium status. Node 101 may for example determine a transmission schedule on a frame by frame basis. Node 101 may update the instantaneous channel knowledge for each frame or subset of frames through channel quality feedback, but predict the source data over a much longer duration from the source data prediction model 511.

FIGURE 5C illustrates an example flow diagram in which at block 526, a node, for example node 111 of FIGURE 1, receives at least one information descriptive of a transmission resource prediction model and determines one or more transmission resource prediction models from the information. At block 524, similar to block 504 of FIGURE 5A, node 111 determines a transmission opportunity, schedule or strategy derived from the transmission resource prediction model.

For example, node 111 may construct a fused transmission resource prediction model comprising the union of a received plurality of information descriptive of a transmission resource prediction model. A transmission resource prediction model constructed in this manner may effectively establish a prediction model predicting that resources are not available if any of the received information descriptive of a transmission resource prediction model predicts the resources not to be available. In an alternative embodiment, the fused data source prediction model may be determined by node 101 using an expectation maximization type algorithm from information descriptive of a prediction model received from a plurality of other nodes, for example nodes 102 and 103 of FIGURE 1. In yet another embodiment, the fused data source prediction model may be determined by node 101 using Gaussian Process based model fusion of the received information.

FIGURE 6 is a block diagram illustrating an example wireless apparatus 600 including a prediction model module in accordance with an example embodiment of the invention. In FIGURE 6, the wireless apparatus 600 may include a processor 615, a memory 614 coupled to the processor 615, and a suitable transceiver 613 having a transmitter and a receiver coupled to the processor 615, coupled to an antenna unit 618. The memory 614 may store computer programs such as a prediction model module 612.

FIGURE 7 illustrates an example flow diagram showing operations for determining and using a prediction model. At block 701, a node, for example node 111 of FIGURE 1, obtains an observation o_l for at least one of L channels. In an example embodiment, node 111 obtains the observation o_l from observing channel l of the at least one of L channels. At block 702, the node receives information descriptive of a prediction model $M_2(S_1,\ldots S_N),\ldots,M_K(S_1,\ldots S_N)$ from *K-1* other nodes. In an example embodiment, each prediction model comprises a Partial Observable Markov Decision Process comprising N states $S_1,\ldots S_N$ for each channel. Node 111 may for example receive $M_2(S_1,\ldots S_N)$ and $M_3(S_1,\ldots S_N)$ from nodes 112 and 113 of FIGURE 1 respectively. The information descriptive of a prediction model may comprise prediction model state information for some or all of the L channels. Assuming channel states for different channels are independent, the prediction model state information for each channel may comprise state transition probabilities $P(S_l'|S_l,a)$ describing the probability of transitioning on channel l to state S_l' from state S_l when action a is taken and observation probabilities $(o_l|\ S_l',\ a)$ describing the probability of obtaining the observation o_l in state S_l' when action a is taken. Each of the K-1 other nodes may also indicate its current state in its prediction model.

At block 703, node 111 updates its own prediction model $M_1(S_1,\ldots S_N)$ by fusing the information descriptive of prediction models $M_2(S_1,\ldots S_N),\ldots,M_K(S_1,\ldots S_N)$ with $M_1(S_1,\ldots S_N)$. Node 111 may for example combine probabilities P obtained in part from its own observations on a channel 1 with probabilities P on channels 2 and 3 received from nodes 112 and 113 respectively.

In this manner, node 111 obtains prediction model $M_1(S_1,...S_N)$ covering three channels while only having sensed one channel itself.

At block 704, node 111 determines a transmission strategy $\Pi(M_1)$ based at least in part on its prediction model $M_1(S_1,...S_N)$. The node may for example determine the transmission strategy as a computation of which action to take given a certain set of probabilities P using a Bellman Optimality Equation. At block 705, node 111 determines which of the L channels to further obtain an observation for. In an example embodiment, node 111 determines which of the L channels to further obtain an observation for based at least in part on the determined transmission strategy.

At block 706, node 111 determines which of the L channels provides a transmission opportunity. In an example embodiment, node 111 determines which of the L channels provides a transmission opportunity based at least in part on the determined transmission strategy. In an example embodiment where the resources on the channels are divided in time-slots, node 111 may execute all blocks of process 700 every time-slot or may for example execute block 706 at every time-slot, but the other blocks substantially less often, for example periodically.

Without in any way limiting the scope, interpretation, or application of the claims appearing below, a technical effect of one or more of the example embodiments disclosed herein is that at least equal awareness of availability of transmission resources can be achieved through less frequent feedback, resulting for example in less collisions in collision-based peer-to-peer networks and higher efficiency in spectrum usage. For example in peer-to-peer networks, obtaining access to the transmission resources can be burdensome and inefficient due to collision avoidance protocols. Sharing a prediction model in one single transmission, with infrequent updating as needed, will result in substantial efficiency gains when compared to frequently sharing instantaneous values carrying the output values of the prediction model. Because in such networks, a design choice is made to lessen the transfer of such instantaneous values to lessen channel access attempts and maintain efficiency, a receiver according to embodiment of the present invention will comparatively be able to extract more accurate and timely information from the prediction model, comparatively improving the awareness of the environment.

Another technical effect of one or more of the example embodiments disclosed herein is that because the receiver may use the prediction model to predict past the current instance, the improved temporal awareness allows improved scheduling decisions by considering both past, current and future conditions, rather than making a decision based on information of the current instance and past conditions only.

Another technical effect of one or more of the example embodiments disclosed herein is that the receiver, to achieve at least an equivalent awareness of the resource occupation, is able to rely substantially less on measuring, resulting in reductions in power usage. Particularly for a node entering an unknown environment in which it may achieve fast initialization of its resource

prediction models from information received from already present transmitters, the time and power usage to become ready to share in the transmission resource usage will be reduced.

Embodiments of the present invention may be implemented in software, hardware, application logic or a combination of software, hardware and application logic. The software, application logic and/or hardware may reside for example on a mobile, communication terminal, base station or access point. If desired, part of the software, application logic and/or hardware may reside on a server connected to the base station or access point. In an example embodiment, the application logic, software or an instruction set is maintained on any one of various conventional computer-readable media. In the context of this document, a "computer-readable medium" may be any media or means that can contain, store, communicate, propagate or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer, with one example of a computer described and depicted in FIGURE 6. A computer-readable medium may comprise a computer-readable storage medium that may be any media or means that can contain or store the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer.

If desired, the different functions discussed herein may be performed in a different order and/or concurrently with each other. Furthermore, if desired, one or more of the above-described functions may be optional or may be combined.

Although various aspects of the invention are set out in the independent claims, other aspects of the invention comprise other combinations of features from the described embodiments and/or the dependent claims with the features of the independent claims, and not solely the combinations explicitly set out in the claims.

It is also noted herein that while the above describes example embodiments of the invention, these descriptions should not be viewed in a limiting sense. Rather, there are several variations and modifications which may be made without departing from the scope of the present invention as defined in the appended claims.

WHAT IS CLAIMED IS

1. A method, comprising:

receiving at a first communication node first information descriptive of a first prediction model from a second communication node; and

determining at the first communication node a second prediction model based at least in part on said first information.

2. The method of claim 1, further comprising:

receiving at the first communication node second information, said second information being descriptive of a third prediction model, from a third communication node; and wherein said determining said second prediction model comprises determining at the first communication node said second prediction model fusing said first and second information.

3. The method of any of claims 1 and 2, further comprising:

determining at the first communication node at least one of a transmission opportunity, a transmission schedule and a transmission strategy using said second prediction model.

4. The method of claim 3, wherein a level of detail of the determined transmission schedule or a selection between determining the transmission schedule or the transmission strategy depends on a perceived level of accuracy of the second prediction model.

5. The method of claim 3, further comprising transmitting said determined at least one of a transmission opportunity, a transmission schedule and a transmission strategy to at least one of said second communication node and a fourth communication node.

6. The method of any of claims 1-5, wherein at least one of said first prediction model and said second prediction model comprises a transmission resource model or a data source model and said first information comprises at least one of a prediction model parameter, a prediction model indicator, a prediction model flow description, a prediction model state transition requirement, a prediction model state transition information and a prediction model prototype state.

7. The method of any of claims 1-6, wherein said first information is received over a peer-to-peer or slave-to-master link.

8. The method of any of claims 1-7, wherein determining said second prediction model further comprises updating or initializing said second prediction model.

9. An apparatus, comprising:

at least one processor; and

at least one memory including computer program code

the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to perform at least the following:

receiving first information descriptive of a first prediction model from a communication node; and

determining a second prediction model using said first information.

10. The apparatus of claim 9, the at least one memory and the computer program code further configured to, with the at least one processor, cause the apparatus to perform at least:

receiving second information, said second information being descriptive of a third prediction model, from a second communication node; and

determining said second prediction model fusing said first and second information.

11. The apparatus of claim 9-10, the at least one memory and the computer program code further configured to, with the at least one processor, cause the apparatus to perform at least:

determining at the first communication node at least one of a transmission opportunity, a transmission schedule and a transmission strategy using said second prediction model.

12. The apparatus of claim 11, wherein a level of detail of the determined transmission schedule or a selection between determining the transmission schedule or the transmission strategy depends on a perceived level of accuracy of said second prediction model.

13. The apparatus of claim 11, the at least one memory and the computer program code further configured to, with the at least one processor, cause the apparatus to perform at least:

transmitting said at least one of a transmission opportunity, a transmission schedule and a transmission strategy from said first communication node to at least one of said communication node and a third communication node.

14. The apparatus of any of claims 9-13 wherein at least one of said first prediction model and said second prediction model comprises a transmission resource prediction model or a data source prediction model and said first information comprises at least one of a prediction model parameter, a prediction model indicator, a prediction model flow description, a prediction model state transition requirement, a prediction model state transition information or a prediction model prototype state.

15. The apparatus of any of claims 9-14, wherein said first information is received over a peer-to-peer or slave-to-master link.

16. The apparatus of any of claims 9-15, the apparatus comprising a base station, an access point, a mobile terminal or a communication terminal.

17. A computer program, comprising:

code for executing the method of any of claims 1-8;

when the computer program is run on a processor.

18. The computer program according to claim 17, wherein the computer program is a computer program product comprising a computer-readable medium bearing computer program code embodied therein for use with a computer.

19. A computer-readable medium encoded with instructions that, when executed by a computer, perform the method according to any of claims 1-8.

20. An apparatus, comprising:

means for receiving first information descriptive of a first prediction model from a communication node; and

means for determining a second prediction model using said first information.

21. The apparatus of claim 20, further comprising

means for receiving second information, said second information descriptive of a third prediction model, from a second communication node; and

means for determining said second prediction model fusing said first and second information.

22. The apparatus of claims 20 or 21, wherein at least one of said first prediction model and said second prediction model comprises a transmission resource prediction model or a data source prediction model and said first information comprises at least one of a prediction model parameter, a prediction model indicator, a prediction model flow description, a prediction model state transition requirement, a prediction model state transition information or a prediction model prototype state.

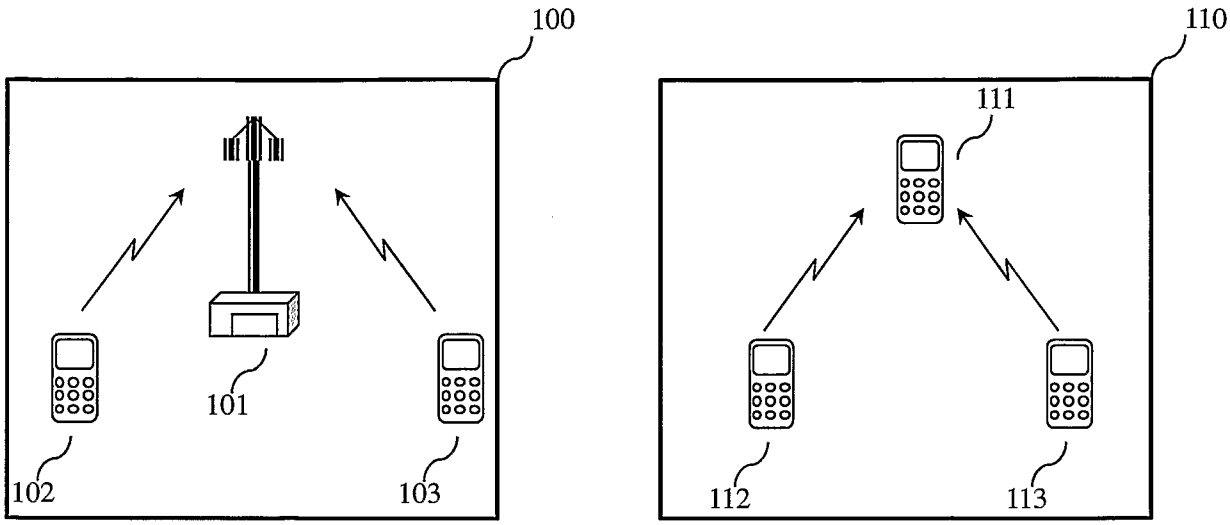


FIGURE 1

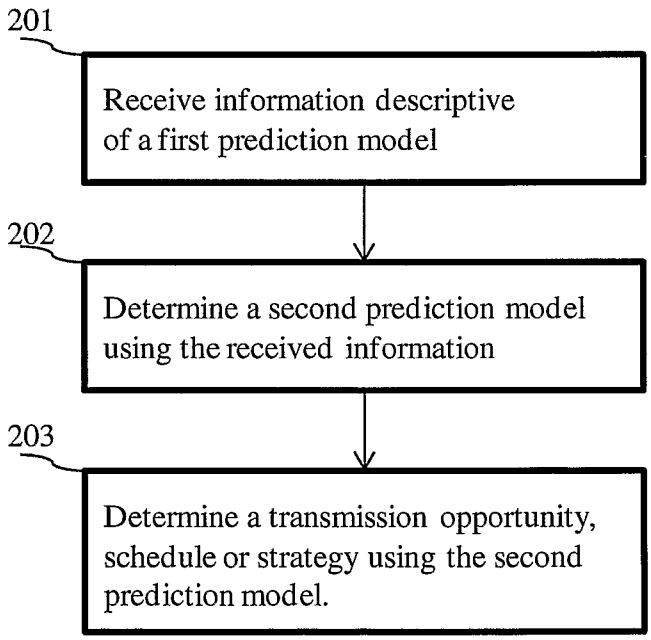


FIGURE 2

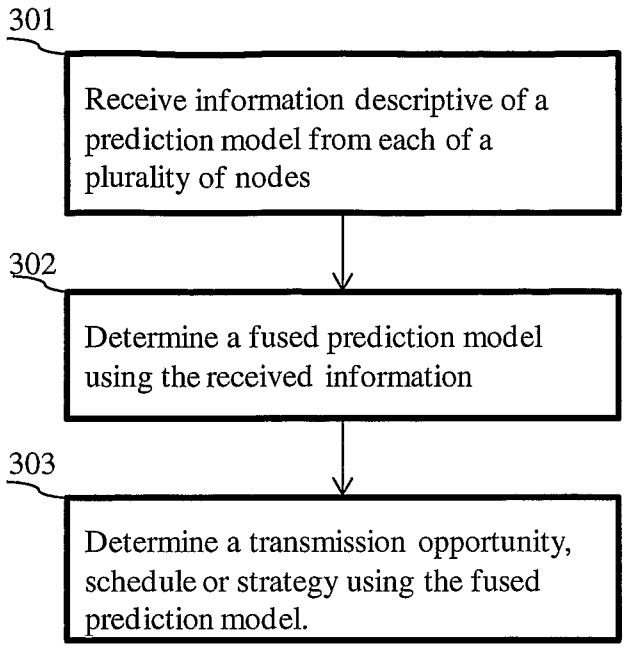


FIGURE 3

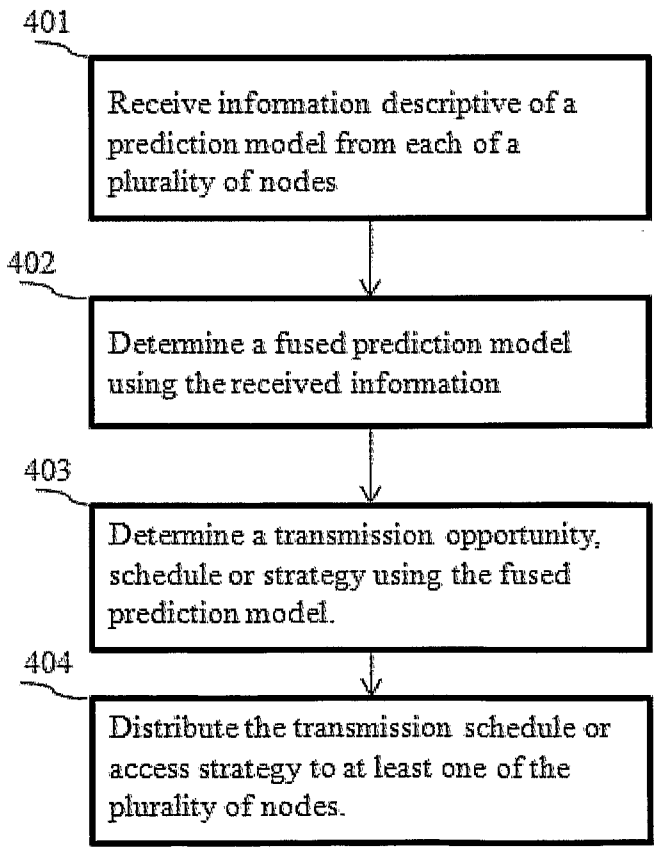


FIGURE 4

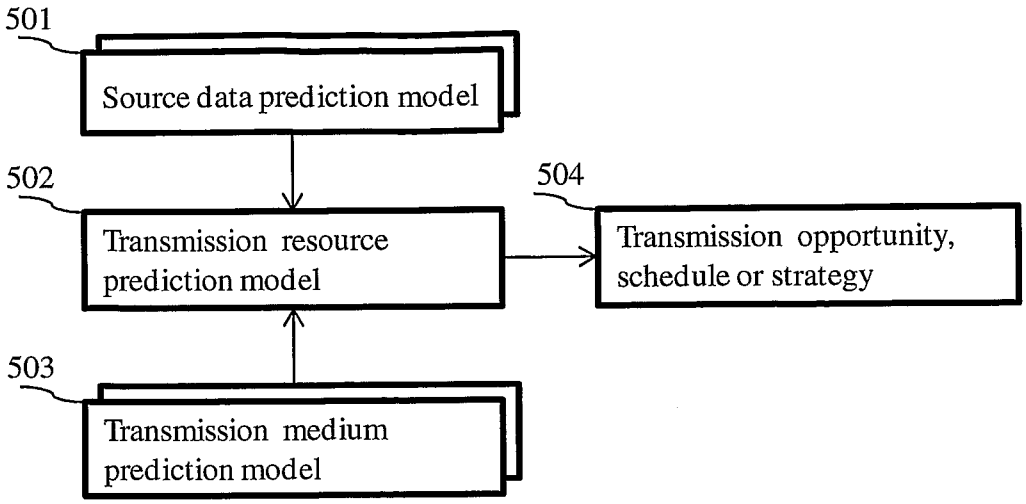


FIGURE 5A

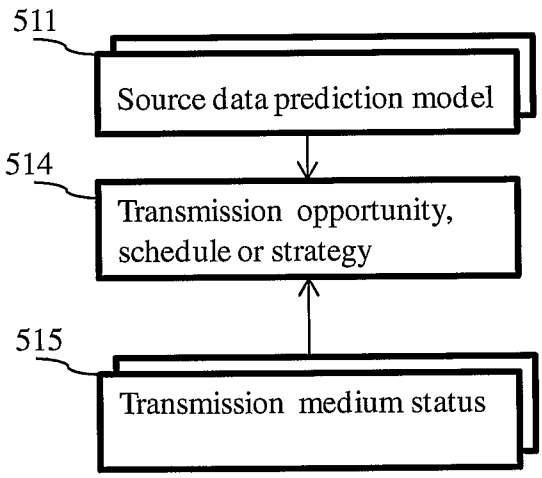


FIGURE 5B

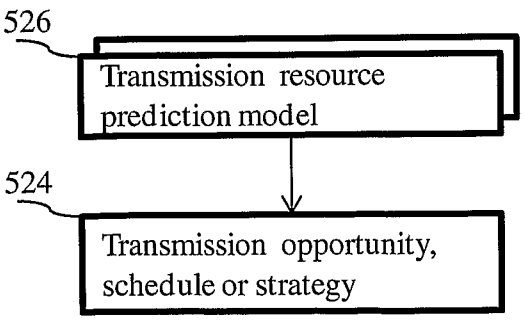


FIGURE 5C

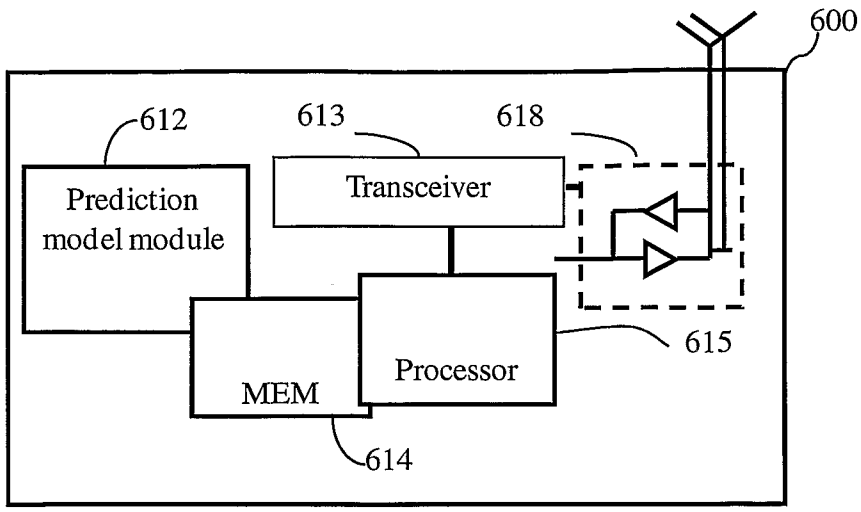


FIGURE 6

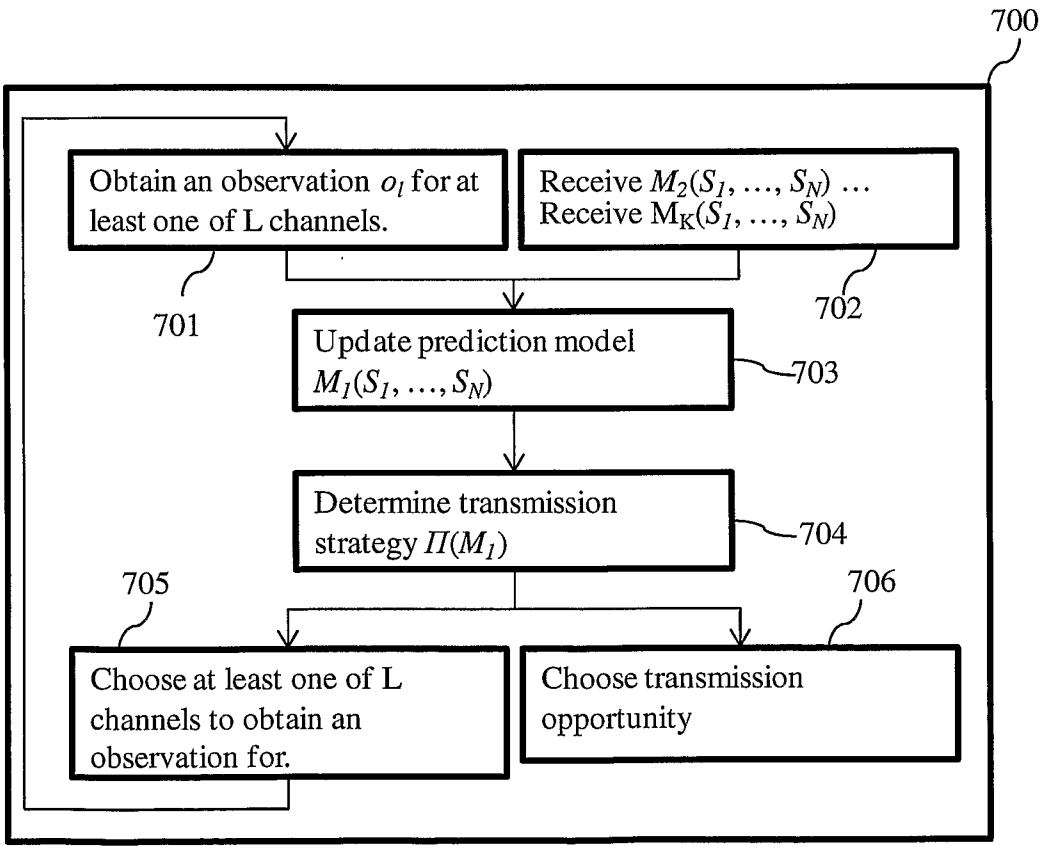


FIGURE 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2010/000762

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04B, H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Gandetto, M.; Regazzoni, C., "Spectrum sensing: A distributed approach for cognitive terminals," Selected Areas in Communications, IEEE Journal on , vol.25, no.3, pp.546-557, April 2007 doi:10.1109/JSAC.2007.070405. URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4155370&isnumber=4155363; paragraphs [0003], [0004], [0005], [0007] --	1-22

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
20-12-2010	21-12-2010
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2010/000762

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Geirhofer, S.; Lang Tong; Sadler, B.M.; , "Cognitive Medium Access: Constraining Interference Based on Experimental Models," Selected Areas in Communications, IEEE Journal on , vol.26, no.1, pp.95-105, Jan. 2008 doi: 10.1109/JSAC.2008.080109 URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4413143&isnumber=4413132 --	1-22
A	US 20070086529 A1 (KRISHNASAWAMY DILIP ET AL), 19 April 2007 (2007-04-19) --	1-22
A	US 20060173559 A1 (KIRSHENBAUM EVAN ET AL), 3 August 2006 (2006-08-03) --	1-22
A	US 20070298811 A1 (HARTMAN MICHAEL JAMES ET AL), 27 December 2007 (2007-12-27) --	1-22
A	US 7680752 B1 (CLUNE III JAMES EDMOND ET AL), 16 March 2010 (2010-03-16) -- --------	1-22

Continuation of: second sheet

International Patent Classification (IPC)

H04W 52/22 (2009.01)
H04B 17/00 (2006.01)

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Cited literature, if any, will be enclosed in paper form.

US	20070086529	A1	19/04/2007	NONE			
US	20060173559	A1	03/08/2006	US	7778715	B2	17/08/2010
US	20070298811	A1	27/12/2007	NONE			
US	7680752	B1	16/03/2010	NONE			