WIRELESS BREAKING SYSTEM

D.Sangeetha Nandhini
E.C.E., Sri Sai Ram Institute of Technology
West Tambaram.

Abstract: **Wireless communication, hard real time requirements and safety criticality do not go together well. Accidents occurs due to the broken of brake wire which is unavoidable. To avoid this, wired brake system is replaced by a wireless brake system. In this paper, the brakes of an ordinary bicycle and are investigating what happens when the mechanical connection is replaced by a wireless sensor and actuator pair.**

I.INTRODUCTION

Braking is nothing about a friction. A brake system in the automobiles is designed to maintain the speed of the vehicle. Various components are required to build a brake system. In this system the vehicle moving energy is converted in to the heat energy.

Friction is nothing but the resistance to movement exerted by two objects on each other. There are two types of friction are used to control the movement of the vehicle

1. Static or stationary friction
2. Kinetic or moving friction

The amount of friction or resistance to the movement depends upon the type of material in contact, the smoothness of their rubbing surfaces and the pressure holding them together. When we are applying the brakes on the moving automobiles the brake pads or brake shoes are pressed against the rotating parts of vehicle. So the kinetic energy or momentum of the vehicle is then converted into the heat energy by the kinetic friction of the rubbing surfaces and the vehicle slows down.

After the vehicle stops, that is after the brakes are released the heat energy of combustion of in engine is converted into kinetic energy by transmission and the vehicles moves.

In this wireless system, the brake in the wireless braking system is activated by the rider simply squeezes on the right side rubber handlebar grip. This pressure sensor in turn activates a small handlebar-mounted sending unit which sends a radio signal to a receiver mounted on the end of the fork, which relays it to an actuator, which activates the disc brake. The components used for the wireless braking system is force sensors, sender, receivers, actuator, replicator, alarm system.

Force Sensor: This sensor is an apparatus which re places the brake handle and produces a digital or analog signal representing the pulled force.

Sender: The sender is located near to the Force Sensor and has a wired connection to it. It reads the signal and sends it using a wireless connection to the Receiver.Receiver: This component receives values from the Sender and demodulates a control signal for the Actuator to a wire.

Actuator: In general this component produces the brake force based on the control signal of the Receiver.

Alarm System: If any problem occurs, the Alarm System has to notify the rider that the brake is not working in this moment.

Replicator(s): To increase reliability we study the option to introduce a node for redundancy. A Replicator component acts as a Sender and a Receiver combined, it listens to the Sender (or all Replicators) and echoes the last value obtained to the Receiver (or to all Replicators).

II.PRINCIPLE DESIGN

2.1. FORCE SENSORS

A transducer is a device that provides an output quantity having a determined relationship to the parameter being measured. In this force sensors are used. This converts the pressure given by the rider to the electrical voltage.Many force transducers employ an elastic load-bearing element or combination of elements. Application of force to the elastic element causes it to deflect and this deflection is then sensed by a secondary transducer which converts it into a measurable output. The output may be in the form of electrical signal as in strain gauge and linear variable differential transducer (LVDT) type load cells or mechanical indications as in proving rings and spring balances. Such transducers are known generically as elastic devices, and form the bulk of all commonly used force transducers. There are a number of different elastic transducer elements but generally they consist of circular rings, cylinders or beams.Then the produced electrical voltage is applied to the sensors.

2.2. SENDERS

Senders are objects which encode message data and transmit the information to one or more receivers. The electrical voltage from the sensor is applied to the senders. Sender encoded signal and transmit that as radio waves or radio signal. This signal is received by a receiver.

2.3. RECEIVERS

A radio receiver is an electronic device that receives radio waves and converts information carried by them to a usable form. It is used with an antenna. The antenna intercepts radio waves and converts them to tiny alternating currents which are applied to the receiver, and the receiver extracts the desired information. The receiver used electronic filters to separate the desired radio frequency signal from all the other signals picked up by the antenna, an electronic amplifier to increase the power of the signal for further processing, and finally recovers the desired information through demodulation. The information produced by the receiver may be sound or image or text.

The radio signal sent by a sender is received by the receiver which is placed on the fork of the front wheel. Then the receiver sends the signal to the actuator.

2.4. REPEATERS

It referred to an electromechanical device used to regenerate telegraph signals. Use of term has continued in telephony and data communications. Repeaters are act either as a sender or a receiver. Repeaters are used to increase the range of a transmitted signal by re-transmission. For a conducted signal, an amplifier is used. Optical systems don't amplify but all these devices give the appearance of doing so. A radio repeater consists of a radio receiver connected to a transmitter. The radio signal is received, amplified and retransmitted, usually on a different frequency.

2.5 ACTUTATOR

An actuator is an electronic device which is used to convert the electrical energy to mechanical torque. The electrical energy is used to actuate equipment such as multi-turn valves. An electrical actuator is one of the cleanest and most readily available forms of actuator because it does not involve oil. In this the electrical signal produced by the receiver is applied to the actuator. It is then convert that signal into the mechanical energy. This energy is then applied to the brake pads.

2.6 .ALARM SYSTEM This alarm system indicates the failure of the braking system. If there is any problem in the braking system, it is indicated by this system by using a led.

III.CONNECTION IMPLEMENTATION

We consider a bike brake, where the communication between the brake handle and the brake shoe is wireless. The wireless design has led us to use a number of components, the force sensor, sender, replicator(s), receiver, actuator and the alarm system.

The bike brake system has very strict real time timing requirements. The time between the rider applying the brake by pressing the handle to the braking force actually being applied has to be short enough to ensure the safety of the rider. The time for applying the brake includes the time for the force sensor to notice the difference in the force being applied, conveying it to the sender, the sender transmitting these values wirelessly to the receiver and its informing the actuator to apply the braking force. The timings of all these steps in the braking process are also limited by the hardware being used.

A regular bike-rider may ride at 30 km/h, i.e. 8 m/s. We have decided that the communication between handle and shoe cannot exceed 150 milliseconds(ms), based on the fact that the actuator mechanics takes 100 ms to react and that adding both intervals leads to 250 ms, which is equivalent to 2 meters (to react). In the bike experiment we configure an alarm system that continuously monitors the connection and alerts the rider whenever this bound is trespassed.

In this, a TDMA-based communication is a good choice to assure time predictable message delivery. In fact, we are using the MyriaNed wireless nodes as basic components.

The node consists of a micro-controller and the radio transceiver. The micro-controller features an integrated analog to digital converter which we use to read a simple force sensor. The radio transceiver operates in the free 2.4 GHz ISM band, so it can be used without a license. The basic setup consists of a total of two nodes, one as receiver and one as sender. After initialization, they communicate via the gMAC protocol, which in this case is essentially a round-based TDMA protocol. A frame is a collection of TDMA slots and frame time is the time spent per frame, thus the sum of the times spent on each TDMA slot. Each communication frame lasts some n ms and each component sends one message to the other component per frame. Throughout the paper, the words frame and round are used interchangeably.

3.1.WIRELESS BRAKE MODEL

The model is based on the assumptions that synchronicity is attained by the gMAC protocol, which is already implemented in the nodes. In the model described here, the probability that an individual message does not arrive at the receiver side is a constant p for each individual message transmitted. The message size is fixed and one message is enough to send the information needed at any time. For the first basic model we consider two logical components following the principal design i.e. Sender and Receiver. The basic unit in Modest is a process, so the overall specification consists of two processes running in parallel, sender and receiver. For the sake of better readability, the presented code is slightly different, and simplified, from the one actually used in the verification. At the end of every frame, ENDFRAME, the timers are reset and the receiver updates the counter lost, that keeps the number of consecutive message losses according to what happened in the frame. In case this counter reaches the established maximum MAXLOST, a flag is raised. This happens immediately, assured by an urgent action crash. In the other case, nothing happens (abstracting from the true operational behavior) but resetting the clock. This is modeled via a tau action, which stands for some action invisible to the outside. The sender is parameterized with a slot number, SLOTSENDER that is unique. The decision adopted for synchronizing is based on slots so the receiver also gets the sender's slot number as a parameter. This enables the receiver to listen to the sender. The processes have two main actions, communicate and reset in every frame. The sender sends the data through a wireless channel abstracted by a shared variable data s indexed by the slot number (for example SLOTSENDER).The receiver is listening and has a probability p of losing the message transmitted, here specified in percent.

3.2. REPLICATORS

Adding redundancy into a system is a classical concept to improve the overall reliability. To experiment with this idea of a replicator network discussed above, we introduce a generic replicator node that acts as a receiver and a sender at the same time. At a glance it is obvious that any type of redundancy will improve the results, but it should be considered that adding a node induces more communication, which in a TDMA setting is naturally accommodated by extending the number of slots per frame accordingly. This means that the more nodes we introduce as senders the longer the frames become. If we want comparable results and we know that we need a reaction within 150 ms we must keep a fixed number of slots. For practical reasons we established 12 slots in 150 ms and we divide the frames accordingly to the number of transmitting nodes. To study the effect of replication, we add in parallel a set of nodes as replicators, extending the model with 1, 2 and 4 replicators. The change to the model is minimal. The behavior of the replicator modeled here is simple (and simplified for the sake of presentation). It basically listens to the sender during the slot SLOTSENDER and with probability p it may not hear the message. Then at SLOTREPLICATOR it replicates the value last received and, again, with a certain probability p the receiver may hear it. We also add an action to listen (with probability p) messages from the replicator without losing the information already received from the sender, thus we use an OR operator. The other actions remain unchanged. For 2 and 4 replicators we did similar changes in the receiver but now we also need to pass all the slots to the replicators and receiver to enable them to listen to other replicators. Since we are interested in not losing more than MAXLOST messages in a row, every receiving node keeps the difference between the frame where it last received message and the actual frame. When this difference in the receiver reaches MAXLOST an alarm is fired.

CONCLUSION

For the safety of the rider, we determine that is imperative that the brake shoe reacts within no more than 250 ms to a command issued by the brake handle. Using a replicator network to add redundancy to the communication is revealed to be counterproductive by the model checker, and by experiments, if one takes the increased round timing into account. Finally, the key to arrive at a safe design is to drastically reduce the individual message loss probabilities. This can be done by using the slot number which is received by the receiver.

REFERENCES

[1] H. Bohnenkamp, P. D'Argenio, H. Hermanns, JP. Katoen. MODEST: A Compositional Modeling Formalism for Hard and Softly Timed Systems. In *IEEE Transactions on Software Engineering*, volume 32(10), pages:812-830, 2006.
[2] A. Hartmanns, H. Hermanns. A Modest Approach to Checking Probabilistic Timed Automata. In *Proceedings of the 6th International Conference on the Quantitative Evaluation of Systems, QEST 2009*, pages: 187-196, IEEE Computer Society Press, September 2009.
[3] F. Heidarian, J. Schmaltz and F.W. Vaandrager. Analysis of a Clock Synchronization Protocol for Wireless Sensor Networks. In A. Cavalcanti and D. Dams, editors, *Proceedings FM 2009: Formal Methods*, volume 5850 of Lecture Notes in Computer Science, pages: 516-531, Springer-Verlag, November 2009.
[4] Highway Addressable Remote Transducer (HART) Protocol. http://www.hartcomm.org/ – accessed on Apr 28, 2011.
[5] S. Juneja, P. Shahabuddin. Rare-event simulation techniques: An introduction and recent advances. In *Handbook of Simulation*, volume 13 of Handbooks in Operations Research and Management Science, pages: 291-350, 2006.
[6] M. Kwiatkowska, G. Norman and D. Parker. PRISM: Probabilistic Model Checking for Performance and Reliability Analysis. In *ACM SIGMETRICS Performance Evaluation Review*, pages: 40-45, March 2009
[7] M. Kwiatkowska, G. Norman and D. Parker. Stochastic Games for Verification of Probabilistic Timed Automata. In *Proceedings of the 7th International Conference on Formal Modeling and Analysis of Timed Systems (FORMATS'09)*, volume 5813 of Lecture Notes in Computer Science, pages: 212-227, Springer-Verlag, September 2009.
[8] E.A. Lee Embedded Software. In M. Zelkowitz, editor, *Advances in Computers*, vol. 56, Academic Press, 2002.
[9] MyriaNedR : large wireless sensor and control network. http: //wsn.chess.nl/ – accessed on Apr 28, 2011.
[10] Modest Toolset. http://www.modestchecker.net/ – accessed on Apr 28, 2011.