Technical journals online.com

Research Paper

SMART COW HEALTH MONITORING, FARM ENVIRONMENTAL MONITORING AND CONTROL SYSTEM USING WIRELESS SENSOR NETWORKS

S. Jegadeesan[1], Dr. G. K. D. Prasanna Venkatesan[2]

Address for Correspondence

[1]Department of ECE, V.S.B Engineering College, Karur, Tamil Nadu, India.

[2]Department of ECE, SNS College of Engineering, Coimbatore, Tamil Nadu, India.

ABSTRACT

Agriculture is the major source of income in countryside areas. Animals like cow, buffalo, sheep, goat etc play an important role in life of rural. They are used as a source of income. Hence animal husbandry becomes a most important concern. Lots of farmers are now torment from different killing diseases and increased breeding costs, *etc.* It is therefore essential for farmers to execute efficient and technical methods to increase productivity and reduce the animal's husbandry. In this study, we illustrate Wireless Sensor Network technology to the farmers. We propose that a Wireless Sensor Networks should be installed on farms to gather ecological which shall then facilitate farmers not only in monitoring the animals via the Web from outside the farm, but also help the control of farm environmental in remote locations. In addition, facilities can be mechanically controlled based on breeding surroundings parameters which are previously set up and a SMS notice service to report of deviations shall provide users with ease. Farmers may increase production through this farm arrangement and prepare a database with information gathered from ecological factors and the farm manage devices, which is estimated to supply information required to propose and execute appropriate control strategies for farm process.

KEY WORDS: Agriculture, Animals monitoring, Farmers, Wireless sensor networks, ZigBee.

1. INTRODUCTION:

Farming industry gives significant income to the Indian nation. But animals in the farms are mostly affected by Foot and Mouth Disease (FMD), Anthrax, Black-quarter (Black-leg), contagious bovine abortion and Bovine mastitis. Due to the above diseases the farmers are suffering heavily. To avoid such things, we introduced a health monitoring application to follow individual animal movement as well as to monitor occurrence of animal diseases is hence important. To monitor the health conditions of each animal (cows), the sensors are mounted on the cow. Sensor networks consist of several tiny, low price devices and are logically self organizing ad hoc systems. The role of the sensor network is monitoring the health parameters of animals, gather and convey the information to other sink nodes. The sensed data from the node is transmitted hop-by-hop towards the sink in a multi-hop manner. The use of energy in the network can be reduced if the amount of data to be transfer is reduced. Wireless sensor network consist of a large number of minute electromechanical sensor nodes which posses the sensing, computing and communication abilities. These devices can be utilized for gather sensory information, like measurement of temperature from the animals.

The very big challenge in the sensor networks is limited amount of resources in the sensor nodes. Therefore, to monitor the health parameters of animals in the pasture field, we like to suggest the mobile sink to receive process and transfer the sensed information from sensors mounted on the animals to the main station. A side consequence of this approach is that the SNs positioned close to the sink are used a lot to dispatch data from all network nodes hence; their energy is consumed more rapidly, leading to a non uniform reduction of energy in the WSN. This domino effect in network disconnections and restricted network lifetime. In such cases, a numeral of representative nodes placed in the border of the sensor pasture field can be used as "rendezvous" points wherein sensed information from neighbor nodes may be collected and finally transmitted to an MS when the latter approaches within radio range.

In this paper, the proposed system is composed of two parts, First part of the system used to monitor and measure the health parameters of animals in the pasture field. Second part of the system used to monitor and measure health parameters of animals in the farm; also it is used to control the environment of the farm remotely to increase the production from the farm animals. Farm environment information and external environmental information are collected through a wireless sensor network formed with sensors installed in the farm, and visual information about the farm is collected and monitored through Closed-circuit television. All this environmental and image information about the farm shall help a user monitoring and controlling the farm facility from outside the farm. In addition, farm facilities could be automatically controlled based on some environment value which is already set up and SMS notice service shall be provided to users when dangerous situation occur.

2. RELATED WORKS:

Farming industry gives significant income to the Indian nation. But animals in the farms are mostly affected by Foot and Mouth Disease (FMD), Anthrax, Black-quarter (Black-leg), contagious bovine abortion and Bovine mastitis. Due to the above diseases the farmers are suffering heavily. In order to solve these problems, it is necessary for farmers to establish an optimal systematic and scientific technology to increase production and decrease the production costs. In this study, we illustrate Wireless Sensor Network technology to the farmers. We propose that a WSN and Closed-circuit television should be installed on farms to gather ecological and image information which shall then facilitate farmers not only in monitoring the animals via the Web from outside the farm, but also help the control of farm facilities in remote locations. WSN is a technology whereby sensor nodes capable of computing and communication are deployed in various application environments so that they can form an independent network, then physical information collected by wireless from the network can be utilized for monitoring and controlling, *etc.*

[3,4]. This WSN technology contributes to realizing high productivity, safety and high human quality of life through its applications in various industries such as distribution, logistics, construction, transportation, military defense and medical services, *etc.* [5, 6]. Nowadays RFID/WSN technology is applied to various agricultural fields such as greenhouses and livestock to achieve high productivity and transparency of distribution routes from the cultivation environment to production management and distribution logistics, *i.e.*, a total monitoring system [7-9]. Especially in the livestock industry, RFID/WSN technology is being used for managing each animal's characteristics, livestock shed environment and for tracking breeding history [10-12]. Mayer *et al.* created a wireless sensor network platform for animal health and behavior monitoring. A steer was equipped with both internal and external sensors, using matchbox sized motes placed inside standard drug release capsules. The nodes monitored the intra-rumenal activity of the steer and communicated wirelessly with each other [13]. Ipema *et al.* described the results of an experiment in which a temperature sensor built into a bolus was placed in the rumen of a cow. The main objective was to demonstrate that capsule-based wireless technology could work in cattle. The mote in the rumen transmitted data to the mote attached to the front leg of the cow; from there the signal was transmitted to the base station [14]. Evaluation of animal welfare can also be accomplished by wireless monitoring and enables the producer to make the right decisions based on real-time management. Nadimi *et al.* addressed and solved the problem of on-line monitoring of cows in an extended area, using ZigBee based wireless sensor networks. A study of wireless sensor networks applied to the monitoring of animal behavior in the field is described. The problem of online monitoring of cows' presence and pasture time in an extended area covered by a strip of new grass using wireless sensor networks has been addressed [15,16]. Monitoring and control of the quality of indoor environment is very important for animal health and welfare and directly impacts productivity and quality. Ventilation in the stables must be managed in order to avoid long-term over-critical exposure of the animals to ammonia, causing stress, pour health and reduced productivity. Cai *et al.* presented a wireless, remote query ammonia sensor that can track both low and high concentrations of ammonia [17].

At the same time, ventilation and heating must be minimized in order to save energy while keeping temperatures at an adequate level. Cugnasca *et al.* evaluated the capability and usefulness of a WSN applied to monitoring environmental variables in an animal housing facility. The nodes were moved through the facility to determine different profiles of temperature, humidity and luminosity [18]. Darr and Zhao developed a wireless data acquisition system for monitoring temperature variations in swine barns [19].

Seasonal and environmental changes may influence hematological values in domestic animals [20]. Thermal environment is a major factor that can negatively affect cow performance, especially in animals of high genetic value. The variation in environmental variables such as ambient temperature, relative humidity, wind and rainfall were recognized as the potential hazards in livestock growth and production. Some species have evolved endogenous annual rhythmicity as an adaptive mechanism to react in advance to regular environmental changes associated with the seasons [21]. Exposure of cows to hot environment could stimulates thermoregulatory mechanisms and produces reduction in the rates of metabolism, feed intake and productivity [22]. In order to maintain homeothermy, an animal must be in thermal equilibrium with its environment, which includes radiation, air temperature, air movement and humidity [23]. Heat stress occurs when any combination of environmental conditions cause the effective temperature of the environment to be higher than the animal's "thermoneutral" zone [24]. Previous studies [23-25] suggested that the temperature-humidity index (THI) could be used as indicator of thermal climatic conditions and of stress degree on cows.

3. MATERIALS AND METHODS:

3.1 Materials:

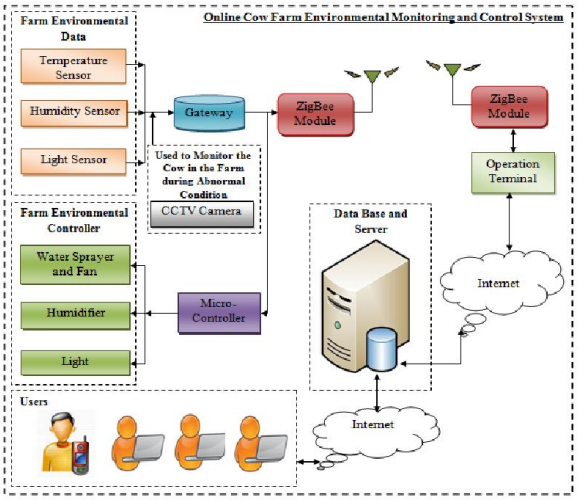

Figure.1. Block diagram of Environment monitor and controller in the cow farm

In the first part of the paper, Figure.1. Sensor nodes are used to sense the environmental data's like temperature, humidity and sunlight in the farm. Gateway is used to collect the information from the sensor nodes and transfer the sensed data to controller, server and remote user via router, ZigBEE and using the internet. Micro controller is used to activate the water sprayer, humidifier and light based on the control information from the controller. The controller is used to control the environment by sending the control information to the micro controller based the sensed data and data which are already stored in the data base.

In the second part of the paper, Figure.2. To monitor the health parameters of the cow in the pasture field in an efficient way, the sensor nodes are mounted on the cow. These sensors form the clusters and select the cluster head, if the cluster heads send data to the static sink; it will consume more amount of energy. To reduce the energy consumption, the mobile sink was introduced, the mobile sinks directly move to cluster heads and get the data from the cluster heads. The problem in the mobile sink is, the cluster head has to wait up to the arrival of mobile sink, due to that buffer overflow may occur. To avoid these problems, we introduced new concept, which is a

numeral of representative nodes placed in the border of the sensor pasture field can be used as "rendezvous" points wherein sensed information from neighbor nodes may be collected and finally transmitted to an MS when the latter approaches within radio range.

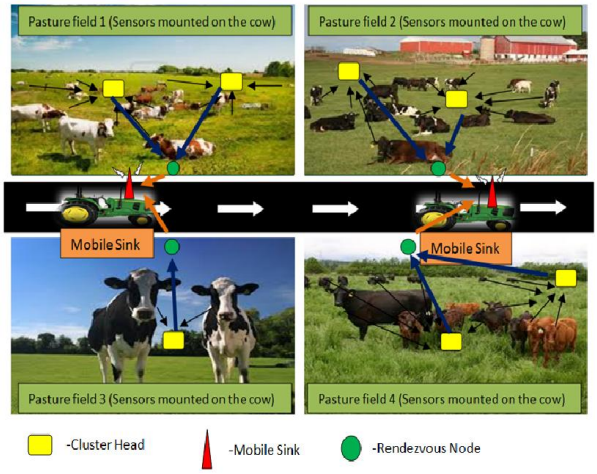

Figure.2. monitoring the animals (Cow) in the pasture field

3.2 Methods:

Considering that environmental conditions are major physiological stressors which affect the animal's biological system, the objective of this study is to maintain the constant environment conditions (Temperature, Humidity and Sunlight) in the cow farm.

Temperature of the farm is sensed by using temperature sensor, if the temperature of the farm is increased or decreased when compared to the threshold value, then the controller activate the water sprayer or fan through micro controller, Humidity of the farm is sensed by humidity sensor, if the humidity of the farm decreased when compared to the threshold value, then the controller activate the humidifier to maintain the humidity of the farm. Sunlight/radiation is sensed the sensor, if the sunlight/radiation is increased or decreased, then the controller switch on or off the light to maintain the illumination in the farm, shown in figure.1.

To monitor the health parameters of cow in the pasture field with energy efficient way using the sensors, we introduced new concept, which is a numeral of representative nodes placed in the border of the sensor pasture field can be used as "rendezvous" points wherein sensed information from neighbor nodes may be collected and finally transmitted to an MS when the latter approaches within radio range.

A main reason of energy spending in WSNs relates with communicating the sensor readings from the sensor nodes (SNs) to remote sinks. The demerit of this approach is that the SNs located close to the sink are heavily used to relay data from all network nodes hence, their energy is consumed more. This leads to reduce the network life time. The single hop relaying consumes less energy when the SNs are located nearer to the base station.

In the existing system Data communication in large wireless sensor network consumes more energy. In the large sensor network leads to retransmission, traffic and error in transmission packets. In addition to that secure data communication in large wireless sensor network is difficult. Data retrieval from the isolated part of wireless sensor network is not efficient.

Our proposed system (Figure.2) aims at minimizing the overall network overhead and energy expenditure associated with the multi-hop data retrieval process. This is achieved through building cluster structures and assigning a cluster head. This performs data filtering and transmits the data to the end nodes. Our proposed system achieve less energy consumption, much less data are buffered at RNs also reducing the probability of buffer overflow at a Rendezvous node. Rendezvous node election process should be takes place based on nodes which are nearer to the mobile sink. It will act as an intermediary between cluster head and mobile sink.

4. RESULTS AND DISCUSSION:

Table 1: Specifications of WSN Environmental Sensor Nodes

Sl.No.	Hardware Type	Hardware Specifications
1	Processor (MSP430F1611)	Data Bus Width: 16 bit Program Memory Size: 48 KB Data RAM Size: 10 KB Maximum Clock Frequency: 8 MHz On-Chip ADC: 8-chx12-bit On-Chip DAC: 2-chx12-bit Number of Programmable I/Os: 48 Interface Type: USART Operating Supply Voltage: 1.8 V to 3.6 V Maximum Operating Temperature: 85 °C Minimum Operating Temperature: −40 °C
2	RF Device (CC2420)	Radio Frequency (Mhz): 2,400 Max. Data Rate (kbits/sec): 250 Antenna: PCB Antenna or SMA
3	Temperature Humidity Sensor (SHT-71)	Vmax (VDD): 2.4–5.5 Humidity range: 0–100% RH Humidity Accuracy: ±3% RH (20–80% RH) Repeatability: ±0.1% RH Temperature Accuracy: ±0.4 °C @ 25 °C
4	Luminance Sensor (GL5547)	Vmax (VDC): 150 Pmax (mW): 100 Ambient Temp (°C): −30~+70 Spectral Peak (nm): 540 Response Time (ms): Rise 20, Decay 30

The variation in environmental variables such as temperature, relative humidity, wind and rainfall were recognized as the potential hazards in livestock growth and production. In-order to increase the production in the farm and to protect the animals from the diseases, we introduced a new concept to maintain the environmental variables temperature, relative humidity and lighting, shown in figure.3. To maintain the environmental variables in the farm, we used a farm environmental controller, in this; it will switch on or off the water sprayer, fan, humidifier and light, based on the farm environmental data. We already set some threshold value for temperature, humidity and luminance.

The live environmental data's are measured in farm environmental data. If the farm environmental data value is increased, when compared to the threshold value, then the system activate the farm environment controller to control the farm environmental variables by switch on or off the water sprayer, fan, humidifier and light. If any problem to the animals in the farm, then we can see the animals activity in the farm by using the CCTV camera. Sensors are mounted on the animals, if the sensed value is abnormal, then it is immediately transferred to farmer to take necessary steps to save the animals and to increase the production.

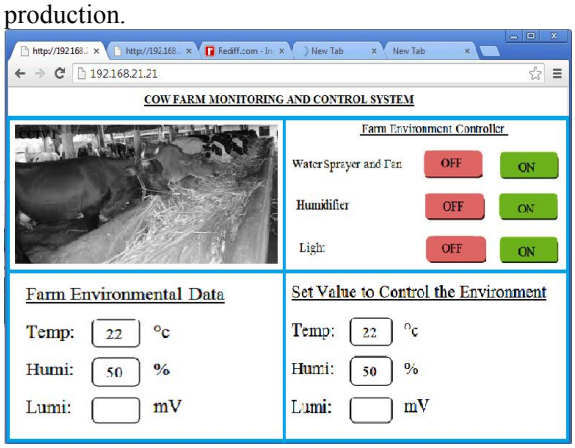

Figure.3. Cow Farm Monitoring System

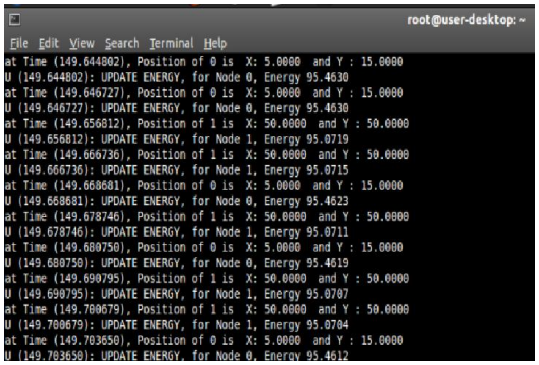

Figure.4. Energy Measurement

In the wireless sensor networks, energy is very important one, so, we have use the energy in an efficient way. Energy measurement during the simulation shown in figure. 4. To utilize the energy efficiently in a wireless sensor network, we introduced a Rendezvous-Based Approach for efficient data collection and secure data communication from farm and pasture field to the user. Sensors are mounted on animals, the sensors sense the data and it is transferred to cluster head, the data's are aggregated and again it is transferred to Rendezvous node to buffer the data. If the mobile sink comes nearer to the Rendezvous node, then the node transfers the buffered data to the sink. From the sink data's are transferred to the server and user.

4.1 Data Aggregation and Forwarding to the RN's:

The steady phase of Mobi-Cluster protocol starts with the interrupted recording of ecological information from sensor nodes with a T_r period. The data collected at individual source nodes are transferred to local Cluster Heads with a T_c period (typically, T_c is a multiple of T_r). Cluster Heads carry out information processing to eliminate data redundancy, which is likely to be present since cluster associates are placed maximum two hops away. Cluster Heads then transfers aggregated information in the direction of remote Cluster Head they are attached to.

4.2 Communication between RNs and Mobile Sinks

The broadcast of information buffered to RNs to MSs. Data communication occur along an intermittently accessible link; hence, a key condition is to decide when the connectivity among an RN and the MS is available. Communication should start while the connection is available and stop while the connection no longer exists, so that the RN does not maintain to broadcast information while the MS is no longer getting it. See the figure (1).To speak to this problem, we use an acknowledgment-based protocol among RNs and MS's. The MS, in all succeeding path traversals after the setup phase, periodically transmits a POLL packet; publicize its presence and soliciting information as it proceeds along the path. The POLL is broadcast at fixed period T_{poll} (typically equal to T_{beacon}). This POLL packet is used by RNs to identify when the MS is within connectivity range. The RN getting the POLL will begin transmitting information packets to the MS. The MS recognize every received information packet to the RN so that the RN understands that the connection is lively and the information was consistently distributed. The recognized information packet can then be cleaned from the RN's cache.

4.3 Secure Data Communication

Encryption and Decryption:

After the choice of the aggregator, each sensor nodes talk with the aggregator, *aggr* using a symmetric key *Kch*, *i.* The sensor nodes transmit the encrypted information through this key to the *aggr.* Then the *aggr* collect the encrypted information and decrypts the information through the same key *Kch*, *i.* Now the *aggr* discover the malicious or compromised nodes, and remove their information in the networks based on *MAC* function every *aggr* decides a *MAC* value for the combined information and finally all the combined information are encrypted and send out to the sink. This information is encrypted by a symmetric key *Kch*, *s.* The sink decrypts the received data by the same key *Kch*, *s.*

4.4 Simulation Result:

In our proposed method is implemented by using NS-2 software, in this simulation we have considered following parameters (Table 2)

Performance metrics are,

Average end-to-end Delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Average Packet Delivery Ratio: It is the ratio of the amount of packets received successfully and the total number of packets transmitted.

Energy Consumption: It is the average energy consumption of all nodes in sending, receiving and forward operations.

No. of Attackers	1,2,3,4,5,6…….50
Area size	1000x1000
Mac	IEEE802.15.4
Simulation Time	50sec
Transmission Range	40m
Routing Protocol	CBQR
Traffic Source	FTP
Packet Size	100
Transmit Power	0.660w
Receiving Power	0.395w
Idle Power	0.335w
Initial Energy	3.1J

Table 2: WSN Parameters

The simulation has been done and result shows that, our proposed system consume less energy than the previous work. See the figure.5.

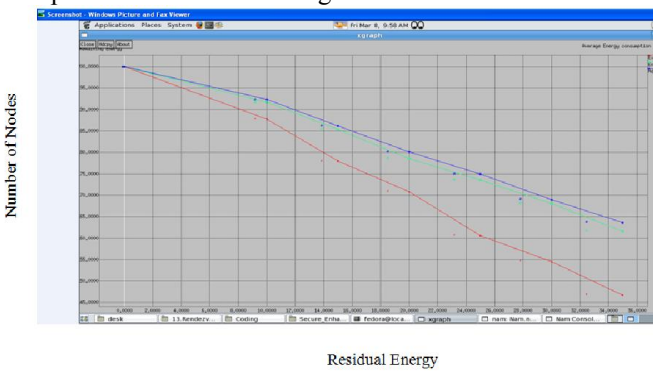

Figure.5. Residual Energy of Sensor Nodes

5. CONCLUSION

Environmental changes (Temperature, Humidity and Light) affect the cow performance through stress and diseases in farm. Also it reduces the farm productivity. Animals and environmental monitoring represent an important class of sensor network applications. Because end users are ultimately interested in the sensor data, the sensor network structure should send the real information to the user. Our proposed system can effectively monitor the health of cow, effectively monitor the environmental parameters in the farm and also it can control the environmental parameters in the farm.

Energy is one of the important factor in the wireless sensor networks. To utilize the energy in an efficient way the Mobi-Cluster protocol was proposed, that uses the urban vehicles to carry MSs that recover information from remote parts of WSNs. Mobi-Cluster primarily intend at make best use of connectivity, data throughput and enabling evenhanded energy spending among SN's. The connectivity purpose is addressed by make use of MSs to gather data from remote urban sensor islands and also all the way through extend the life span of selected peripheral RNs which lie within the range of passing MSs and used to cache and send sensory resulting data from remote source nodes. Improved data throughput is guarantee by modifiable the number of RNs for allowing enough time to send their buffered data and avoid data losses. Unlike other approaches, Mobile Cluster moves the processing and data transmission trouble away from the vital border nodes (RNs) and allow evenhanded energy expenditure across the WSN through building cluster structures that exploit the high redundancy of data gathered from neighbor nodes and reduce inter cluster information overhead. We also inbuilt data encryption and decryption in this paper which provides more secure communication between the nodes.

REFERENCES:

[1] Lee, J.-H. *What is a threat to South Korea's livestock industry*? Focus attention GSnJ No.55; Livestock Industry Research Series 11; GS&J Institute: Seoul, Korea, March 2008.

[2] Yoo, Y.-H.; Kim, D.-H. The current state of automation in pig house establishment and prospection. In *Proceedings of The 11th Conference of Korea Society for Livestock Housing and Environment*, Seoul, Korea, February 2006; Volume 1, pp. 29-47.

[3] Akyildiz, I.F.; Su, W.; Sankarasubramaniam, Y.; Cayirci, E. A survey on Sensor Networks. *IEEE Commun. Mag.* 2002, *40*, 102-114.

[4] Chong, C.Y.; Kumar, S.P.; Hamilton, B.A. Sensor networks: Evolution, opportunities, and challenges. *Proc. IEEE* 2003, *91*, 1247-1256.

[5] Pyo, C.-S.; Chea, J.-S. Next-generation RFID/USN technology development prospects. *Korea Inform1. Commun. Soc. Inform. Commun.* 2007, *24*, 7-13.

[6] Park, D.-H.; Kang, B.-J.; Cho, K.-R.; Sin, C.-S.; Cho, S.-E.; Park, J.-W.; Yang, W.-M. A Study on Greenhouse Automatic Control System Based on Wireless Sensor Network. *Wireless Pers. Commun.*2009, doi: 10.1007/s11277-009-9881-2.

[7] Jeong, B.-M. *Foreign u-Farm Service Model Casebook*; Issues and Analysis Report of Korea National Information Society Agency, NCA V–RER-06005; Korea National Information Society Agency: Seoul, Korea, October 2006.

[8] Kwon, O.-B.; Kim, J.-H. *A Basic Direction for Building Agricultural Radio Frequency Identification Logistics Information System*. M85; Korea Rural Economics Institute: Seoul, Korea, December 2007.

[9] Lee, M.-H.; Shin, C.-S.; Jo, Y.-Y.; Yoe, H. Implementation of Green House Integrated Management System In Ubiquitous Agricultural Environments. *J. KIISE* 2009, *27*, 21-26.

[10] Yoo, N.; Song, G.; Yoo, J.; Yang, S.; Son, C.; Koh, J.; Kim, W. Design and implementation of the management system of cultivation and tracking for agricultural products using USN. *J. KIISE* 2009, *15*, 617-674.

[11] Lee, S.-C.; Kwon, H.; Kim, H.-C.; Kwak, H.-Y. A design and implementation of Traceability System of black pigs using RFID. *J. Korea C. Assoc.* 2008, *8*, 33-40.

[12] Kim, M.; Son, B.; Kim, D.K.; Kim, J. Agricultural Products Traceability Management System based on RFID/USN. *J. KIISE* 2009, *15*, 331-343.

[13] Mayer, K.; Ellis, K.; Taylor, K. Cattle health monitoring using wireless sensor networks", In *Proceedings of the Communication and Computer Networks Conference (CCN 2004)*, Cambridge, MA, USA, November 2004.

[14] Ipema, A.H.; Goense, D.; Hogewerf, P.H.; Houwers, H.W.J.; van Roest, H. Pilot study to monitor body temperature of dairy cows with a rumen bolus. *Comput. Electron. Agric.* 2008, *64*, 49-52.

[15] Nadimi, E.S.; Sogaard, H.T.; Bak, T.; Oudshoorn, F.W. ZigBee-based wireless sensor networks for monitoring animal presence and pasture time in a strip of new grass. *Comput. Electron. Agric.* 2008, *61*, 79-87.

[16] Nadimi, E.S.; Sogaard, H.T.; Bak, T. ZigBee-based wireless sensor networks for classifying the behaviour of a herd of animals using classification trees. *Biosyst. Eng.* 2008, *100*, 167-176.

[17] Cai, Q.Y.; Jain, M.K.; Grimes, C.A. A wireless, remote query ammonia sensor. *Sens. Actuat. B Chem.* 2001, *77*, 614-619.

[18] Cugnasca, C.E.; Saraiva, A.M.; Naas, I.D.A.; de Moura, D.J.; Ceschini, G.W. Ad Hoc Wireless Sensor Networks applied to animal welfare research. In *Proceedings of Livestock Environment VIII. ASABE*

Eighth International Symposium, Iguassu Falls, Brazil, 4 September 2008.

[19] Darr, M.J.; Zhao, L. A wireless data acquisition system for monitoring temperature variations in swine barns. In *Proceedings of Livestock Environment VIII. ASABE Eighth International Symposium*, Iguassu Falls, Brazil, September 2008.

[20] Feldman B.F., Zinkl J.G., Jain N.C. (2002). Schalm's Veterinary Hematology. Lippincott Williams and Wilkins, Philadelphia, Baltimore, New York, London, Buenos Aires, Hong Kong, Sydney, Tokyo.

[21] Piccione G., Giannetto C., Casella S., Caola G. (2009). Annual rhythms of some physiological parameters inOvis aries andCapra hircus. Biol. Rhythm Res., 40: 455-464.

[22] Abdelatif A.M., Alameen A.O. (2012). Influence of season and pregnancy on thermal and haemotological responses of crossbred dairy cows in a tropical environment. Global Veterinaria, 9(3): 334-340.

[23] Kadzere C.T., Murphy M.R., Silanikove N., Maltz E. (2002). Heat stress in lactating dairy cows: a review. Livestock Period. Sci., 77(1): 59-91.

[24] Armstrong D.V. (1994). Heat Stress Interaction with Shade and Cooling. J. Dairy Sci., 77(7): 2044-2050.

[25] Dikmen S., Hansen P.J. (2009). Is the temperature-humidity index the best indicator of heat stress in lactating dairy cows in a subtropical environment? J. Dairy Sci., 92: 109–116.