Wireless sensor networks with cloud computing data collection by using Data Prediction Model

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Abstract

Wireless Sensor Network (WSN) has been a centre of attention for research for numerous years. WSN allows novel and smart answers for information gathering through the spectrum of Endeavour comprising transportation, commercial, health-care, business automation, and environmental monitoring, WSN is not getting sufficient use due to low battery power and memory capacity. Cloud computing has numerous inherent benefits such as, well-organized practise of assets, scalability, elasticity, and rapid development and introduction of new applications. Resources as dedicated to them whereas in reality multiple users access them concurrently. Cloud have a large data storing capacity but not unlimited, in this paper we propose a prediction based data gathering mechanism which is based on combination of Kalman Filters and Gray Model data aggregation, result shows the reducing of data redundancies and improve life time of WSN as well as cloud.

INTRODUCTION

Wireless sensor networks is a combination of various sensor nodes which provide great role in the field of data gathering and monitoring in remote areas, Each WSN consist of various cluster and each cluster have a cluster head and various other node[1], all nodes are collect data and send to respective cluster head and transmit to base station. WSN allows novel and smart answers for information gathering through the spectrum of endeavor comprising transportation, commercial, health-care, business automation, and environmental monitoring[3]. Despite these improvements, the exponentially increasing data mined from WSN is not getting sufficient use due to the deficiency of expertise, time and money with which the data might be better explored and stored for future use[2]. Cloud computing bargains elastic provisioning of large-scale infrastructures to numerous simultaneous users. Cloud computing[4] has numerous inherent benefits such as, well-organized practice of assets, scalability, elasticity, and rapid development and introduction of new applications. Resources as dedicated to them whereas in reality multiple users access them concurrently. The ability of sensor node is continuously data sensing, processing and collecting from outside world due to this the battery lifetime is reduced and more energy will waste, while some time a large redundant data will also captured by sensor node and it also decrease the battery life as well as occupy large memory space[5]. If we reduce redundant data capturing from sensor node, it will increase battery life of sensor node and also reduce memory space. The prediction method may best solution for achieving this, by using prediction method we reduce redundant data collection, it take only predicted value rather than actual value and also reduce sample transmission in particular area while continuous measurement. Same things applied on cloud There are various approach for data prediction in WSN like Grey-Model-based Data Aggregation (GMDA), Kalman-Filter based Data Aggregation (KFDA) and Combined Grey model and Kalman Filter based Data Aggregation.

This paper proposed a prediction based data collection method for wireless sensor network and which data stored at cloud side, this phenomenon provide more battery life of sensor node as well as reduce memory consumption for both side WSN and cloud, by using it the redundant data will reduced by 40% and memory space increase by 30% hence it may provide the solution of drawback of WSN.

The rest of the paper is contained as follows: The second section include brief overview about related work. The third section include prediction scheme and fourth section contain algorithm and simulation result. Last section contain conclusion of research work.

Related Work

Various technique and Theory are proposed for data collection and gathering in WSN with reducing communication and increasing battery life as well as memory space in sensor node and also cloud side. Most of these technique are based on time series forecasting and follow simple heuristics method[5]. Data reduction is mainly on two basics first is data compression and other is data prediction, in the data compression the information which is collected by source node is compressed but in the prediction method which is reduced redundant data.

The well known Kalman filter is very useful algorithms for prediction based data collection, basically Kalman Filters is used in almost all Global positioning system receivers and other equipment like radio and wireless sets[4]. Romer and Santini in[7] use least mean square compare to Kalman Filter because in LMS does not required priori knowledge of desired measurement. Which implies that sink and sensor both data collection does not agree for prediction. Olston et al. in[8] proposed a dual prediction technique which use a constant prediction to provide the user for bounded interval which is computed based on users specified precision constant alfa .

R. Rajagopalan[6] also proposed a Model-driven data aggregation approaches which is very useful to remove redundancy and reduce transmissions among sensor nodes as well as increasing battery life of sensor node. The aggregation process is done between the sink and source node, after aggregation the minor difference is occurred between original and aggregated data. Anastasi et al. [7] classified a data aggregation approach in three types such as stochastic approaches, algorithmic and time series forecasting approaches which provide a properly and systematic energy reducing scheme. A data prediction scheme based on a probabilistic model is proposed by Deshpande [8] it is useful to reduce data

transmission and reduce the quantity of data acquisition another stochastic approach KEN [9] also proposed based on dynamic probabilistic to reduce communication between sensor node and base station. In this process the communication is not needed between sensor node and base station except when the sensor node senses anomalous data. Guiyi Wei et al[10]proposed a novel prediction-based data collection protocol, where a double-queue mechanism is designed to synchronize the prediction data series of the sensor node and the sink node, and therefore, the cumulative error of continuous predictions is reduced. On the basis of that protocol, well defined prediction-based data aggregation approaches are proposed: Kalman-Filterbased Data Aggregation (KFDA) Grey-Model-based Data Aggregation (GMDA), and Combining the Grey model and Kalman Filter Data Aggregation (CoGKDA). On integrating the grey model and Kalman Filter in processing data series noise, CoGKDA presents high prediction accuracy, low communication overhead, and increasing battery life time and relative low computational complexity. A dual prediction scheme also proposed by Carmalatta J [11] which is made for cluster based wireless sensor network and applicable for environmental monitoring where data may be lost due to single node failure and he suggests that source and destination node always give same data prediction values and increase battery life as well as decrease transmission rate.

According to IBM report cloud is a new consumption and delivery model for IT based services where the user see only the service and has no need to know anything about technology or implementation. Basically three types of services are provided by cloud computing software as a service(SaSS) platform as a service (PaaS) and Infrastructure as a service (IaaS). Customer can utilize network, storage and other recourses at cloud on the basis of pay per use or provide very low cost as compared to establishing setup. Hassan et. el [12] proposed a new events matching algorithm for integrating wireless sensor network and cloud computing and applicable in publish broker. another architecture is also proposed by Lee and Hughes [13] applicable for tangible cloud computing and use to implement cloud.

Data Prediction Model

sensor is a small low battery power device which have the ability to collecting information, gathering data and transmitting to base station, due to low battery power and low computational speed we cannot utilize all feature of sensor node to overcome its drawback we integrate wireless sensor network with cloud computing and apply prediction method for same. On integration of cloud with WSN will increase the unlimited storage capacity of sensor node while prediction method is indirectly increasing battery life as well as remove redundant data so increasing storage capacity[6].

There are various prediction and aggression model available like Kalman Filter, Gray model and Dual Kalman filter etc, but most popular Kalman Filter is oldest data fusion algorithm in the field of information processing and Global positioning system, satellites navigation system. its most important achievement is used in Apollo navigation computer center which took Neel Armstrong to Moon surface and brought him back to earth surface successfully.[13]

Prediction is applicable to conclude missing value applying estimation of future value basis on previous value. Let we consider a WSN where various number of nodes and a cluster head, lifetime of each sensor node is divided in to equal time period, at both ends sink and sensor node apply same prediction algorithm. Sensor node send data to sink after verify the threshold error value and commutative predictive error value if satisfy after neglect particular error e(n) only the condition fulfill. Let P(n) is the total sensor node reading while n is the number of nodes.

According to the Kalman Filter the state of a system at a time t evolved from at prior state at time t-1 followed by given equation

P(t) = U(t)P(t-1) + V(t)L(t) + W(t) 1

Where P(t) represent predicted data at time t and U(t) represent the state transmission model applied at previous state (t-1) time period. V(t) represent the control input which applied on each control input parameter in the vector L(t). **W**(t) represent the vector containing the process noise terms for each parameter in state vector mostly noise is assumed to be zero.

Actual measurement perform by the equation

Z(t) = H(t)X(t) + V(t) ………………..2

Where H(t) denotes the transformation matrix that help to calculate vector parameter for measurement of actual sensed data at time period t. here Z(t) is used for calculating actual data. V(t) is noise which is assumed to be zero mean Gaussian white noise. Basically Kalman filters conclude on two phased prediction and updating, prediction phase use data estimation from previous sensed time period at t-1 to produce at estimation of data at time period t as current period on the other hand at update phase used the current data and remove unwanted element or filtered redundant data from current state and generate actual data for current time period.

Pt/t-1 =UtPt-1/t-1 + V(t)U(t) ……………3

Gt/t-1 = UtGt-1/t-1Ut^T + QT …………4

Gt is a matrix of Gaussian and covariance function in one dimensional linear system with zero error for Gaussian distribution. The variant associated with the unknown true value Xt predicted by Xt/t-1.

Gt/t-1 = E[(xt-x't/t-1)$(xt-xt'/t-1)^T$] …… 5

Xt-x't/t-1 = F(xt-1 – x't/t-1) + Wt ……..6

While on putting the value of xt-x't/t-1 in equation 5 then we get,

Gt/t-1 = E[F(xt-1 –x't/t-1) + Wt X F(xt-1 – x't-1/t-1) + $Wt)^T$] …………………..7

Assume the process noise and estimation error will zero we get.

E[(xt-1 – x't-1/t-1)$Wt^{T]}$ …………8

= E[Wt/xt-1 – $xt-1/t-1)^T$) = 0

So

$Gt/t-1 = FE(xt-1 - x't-1/t-1)(xt-1 - x't-1)^T] F^T + E(WtWt^T)$.

Hence

$Gt/t-1 = EPt-1/t-1F^T + Qt$. ………………9

Gt/t = **G**t/t-1 - **K**t**H**t**G**t/t-1 ……………10

X't/t = x't/t-1 + Kt(Zt-Htx't/t-1) ……….11

Experiment and performance evolution

In the wireless sensor network the data collection at the application layer is done on three basics, firstly sensor node collect data from Physical layer and caches it locally it send to sink node only when sink node get request for it, secondly things sensor node collect data and immediately transfer to sink node without using any prediction scheme in both condition unnecessary or redundant data may stored at data center and consume large space as well as increasing transmission rate that reduce battery life for over come this situation a proposed prediction method will used. In that phenomena both condition is applicable data is collected and transmit to sink node after prediction. Some drawback is also found for prediction method, if for a long time data is predicted at sensor node and not a single data send to sink node in that situation sink node may assume that sensor node will unattended or it may be failed for that condition a additional threshold v is applied which is send same data to sink node after certain interval, it reduce commutative error.

To evaluate the data prediction approach. We apply the value xt/t and x't/t-1 with kalman Filter accuracy finding by taking these value using root mean square error formula for without predicted data series and collect data after predicted data then we find the difference between both data set in the terms of temperature and threshold, this calculation gives the difference between both data.

Result analysis

let we consider xt+1 is actual sensed data at sensor node and x't+1 is predicted data at sensor nod and same algorithm is applicable at sink node then x''t+1 data is collected by sink node, then we find the absolute value in terms of threshold and communication over head on both situation normal and prediction, consider absolute(x't+1 - xt) < ϵ and abs(x't+1 – xt-1) < 0

on applying root mean square error on sampled data

R=

$$\sqrt{\frac{(predicted\ value - actualvalue)2}{(no\ of\ element\ predicted)}}$$

We get commutative energy saving is goes to 32% on applying ϵ is 0.5 while using ϵ is 1 it get 57% energy saving and also on the prediction threshold it goes to increase at level 0 to 6.6 while communication energy saving is also give good result to 46% at prediction based on comparisons with normal data collection method.

In given graph we shown the result between the weight vector of sensor node as communication overhead and the successful prediction rate it gives the result varies on different values of ϵ it gives result on 0.5 and 1 that shows at certain interval t we conclude that it gives best accurate at 20 times period. Again in compare with prediction threshold with normal condition and predicted condition in fig 2.

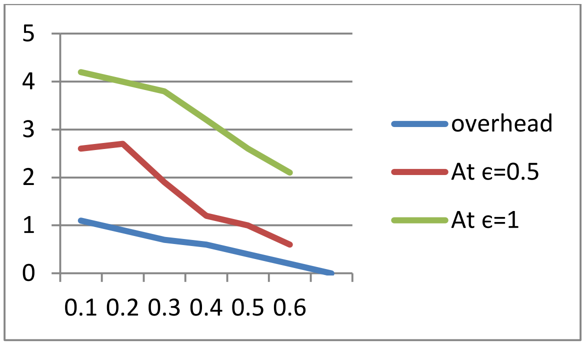

Figure -1 successful prediction rate.

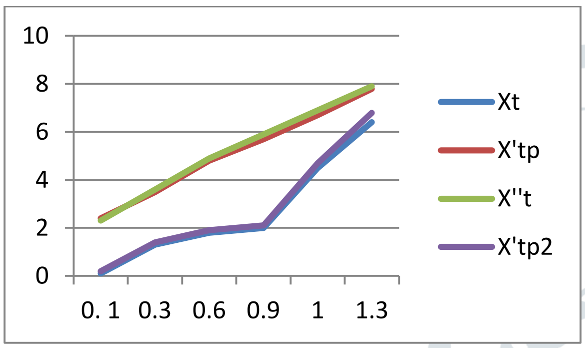

Figure – 2 parameter error

In figure 2 we conclude the data rate at xt is normal data collection at sensor node while x't predicted data collection at sensor node and at same time normal data collection at sink node is denote by x''t and x'tp is predicted data collection at sink node, we find that the energy conversation is goes to approx 57% on data collection by prediction method.

Conclusion

on the basis of above experimental result we say that data prediction method is very useful it reduce the data redundancy and improve the battery life of sensor node it may help in sensor as well as cloud because cloud is not an unlimited source of data collection this things may reduce drawback of sensor node and increase usability of sensor node.

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