Short Course of LaTeX

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I. Introduction

The wireless mesh network (WMN) is a kind of ad-hoc networks, where nodes are willing to forward data for other nodes and the transmission path is determined dynamically based on the network connectivity, with full or partial mesh topologies.

II. Overview

A. Atmospheric dispersion modeling

In order to simulate the air pollution, we find out a well known air dispersion model which is a partial differential equation based on the law of conservation of mass. The solution of this differential equation can give us a function coordination to calculate the mass concentration of every point in the space.

B. Scenario

In the atmospheric dispersion model we assumed that the wind speed and direction is already known. However, in more realize case this assumption is over ideal assumption. Hence, based on this model, we relax the restriction of information about wind and make the wind speed as a random variable with some resonable distribution. Then we set up the pollutant concentration sensor which distributed uniformly as the cellular base station.

C. Algorithm

When the pollutant is spreading in the space, the sensor start sensing the pollutant concentration nearby itself, and re-transmitted the data back to the cluster head. After that, server will reconstruct the pollutant distribution map which can point out that some certain area suffer from the pollutant seriously. On the other hand, our wireless sensor might be restricted by the channel capacity, and not all of the sensor could transmit data to cluster head. According to the scenario, we can derive a optimization problem with the entropy as the objective function, in order to solve this problem, we apply the cross entropy algorithm to find the approximate solution.

D. Performance analysis

After the approximate solution is derived, we can conclude that the mean square error of reconstruction map will be bounded through theoretical result of information theory. Meanwhile, in order to validate the theoretical bound, we keep the air dispersion modeling result as the theoretical value and the reconstruction value as the measure value, and we can calculate the the mean square error from these two part of result. Considering the mean square result, we can verify if the experiment result is consist with the theoretical bound.

TABLE I
CHARACTERISTICS

	Specific Heats	
	c (J/kg·K)	C (J/mol·K)
Aluminum	900	24.3
Copper	385	24.4
Gold	130	25.6
Steel/Iron	450	25.0
Lead	130	26.8
Mercury	140	28.0
Water	4190	75.4
Ice (-10 °C)	2100	38

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- first big item
- second big item
  - first small item
  - second small item
- third big item

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1) first big item
2) second big item
   a) first small item
   b) second small item
3) third big item

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Bill first big item
Mary second big item
    Soft first small item
    Hard second small item
Jack third big item

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III. Algorithm

A. Introduction to cross entropy algorithm

a) Motivation: Cross entropy is already applied to solve some complicate optimization problems, such as travelling salesman problem(TSP), and the max-cut problem. On the other hand, cross entropy can also be used to perform rare event-simulation. Consider the property of our problem, we can figure out that if we want to determine a certain node should be chosen or not to be chosen base on the probability indicate by the algorithm output, this output must be fairly approach to 0 or 1. And this property is consist of the cross entropy in rare-event simulation. Hence we would like to use cross entropy algorithm to find the optimization solution of our sensor selection problem.

b) Brief description: To apply the cross entropy algorithm. The constraint and objective must be specified, which will be propose in the following subsection. After that, the CE method involves an iterative procedure where each iteration can be broken down into two phases.

1) Generate a random data sample (trajectories, vectors, etc.) according to a specified mechanism.
2) Update the parameters of the random mechanism based on the data to produce better sample in the next iteration.

After iteration which is large enough, we can make the parameter as our optimization solution.

B. Set up

C. Finding the optimization solution

IV. Model of Video Streaming

A. Video Distortion Model

In [3], it introduces this video distortion model. For this concurrent video streaming application, video packets are transmitted over the wireless mesh network and need to meet their playout deadline. Then the decoded video distortion, D_{dec}, is given by:

$$D^{dec} = D_{enc} + D_{loss} \tag{1}$$

$$D_{enc} = D_0 + \theta/(R - R_0) \tag{2}$$

$$D_{loss} = k(P_v + [1 - P_v](1 - P(T_v > \delta_v))) \tag{3}$$

. In [3], the parameters of the model are $D_0 = 0.49$, $\theta = 1222$, $R_0 = 10.39kbps$, $k = 185$.

B. Network Model

Before we introduce the network model, we should define some parameters first [1], [2], [4]. Consider a WMN with N nodes distributed on a plane with c_{ij} as the distance between two nodes i and j. Each wireless mesh node is equipped with a radio having transmission range r_i and interference range r_i'. Hence, we can model such a WMN by a directed graph $\mathbf{G} = \mathbf{G}(\mathbf{N}, \mathbf{L})$, where $\mathbf{N}$ represents the set of nodes in the WMN, and $\mathbf{L}$ represents the set of wireless directed links between nodes. A direct link $\{ij\}$ exists from node i to node j if $c_{ij} \le r_i$ and $i \ne j$. We characterize link $\{ij\} \in \mathbf{L}$ using:

Besides, we let the path of video clip v be L_v, which includes a set of link $\{ij\}$. For each link $\{ij\}$ we define an index variable:

$$X_{ij}^v = \begin{cases} 1, & \{ij\} \in L_v \\ 0, & \{ij\} \notin L_v \end{cases} \quad \forall\{ij\} \in \mathbf{L}, \forall v \in \mathbf{V} \tag{4}$$

1) Packet loss rate and delay: Assume that the bit error rate (BER) on link $\{ij\}$ is e_{ij}, and S is the average packet size. Then the end-to-end packet loss rate associated with path L_v can be defined as:

$$P_v = 1 - \prod_{\{ij\} \in \mathbf{L}} (1 - X_{ij}^v), \forall v \in \mathbf{V} \tag{5}$$

$P_{ij} = 1 - (1 - e_{ij})^S$ is the packet loss on link $\{ij\}$.

2) Interference model: To model the delay, we assume the delay t_{ij} on link $\{ij\}$ is an exponential distribution with the probability density function $f_{t_{ij}}(x) \sim \lambda e^{-\lambda_{ij} x}$, $\forall\{ij\} \in \mathbf{L}$. As a result, the end-to-end delay for path L_v can be derived as:

When the number of hops along L_v is not large enough, we use the moment generating function, $G_{T_v(s)}$, to find the probability that the packet streamed over path L_v has delivery delay longer than δ_v. Then we can get this probability, $P(T_v > \delta_v)$, when the number of hops is small as [5]:

$$\begin{aligned} P(T_v > \delta_v) &= \int_{\delta_v}^{\infty} f_{T_v}(x)\, dx \\ &= \sum_{\{ij\} \in L_v} \{(\lambda_{ij} - X_{ij}^v s) G_{T_v(s)}\} \,|_{s=\lambda_{ij}} \end{aligned} \tag{6}$$

3) Aggregated traffic: In this part, we want to model the total traffic on the link $\{ij\}$. And we define L_v^i as the sub-path which includes all the links along the path L_v up to the link $\{ij\}$. Therefore, we can derived the total traffic on link $\{ij\}$, ρ_{ij}, as:

$$\rho_{ij} = \sum_{v \in \mathbf{V}} \prod_{\{kn\} \in L_v^i} \{(1 - P_{kn}) X_{kn}^v\} \times R_v, \forall\{ij\} \in \mathbf{L} \tag{7}$$

C. Route selection

Moreover, the aggregate traffic on each link $\{ij\}$ should be guaranteed that it can not exceed its available bandwidth R_{ij}. Hence, the problem of routing loop also should be prevented. After concluding the above constraints, we can formulate the optimal route selection problem as: given a WMN $\mathbf{G}(\mathbf{N}, \mathbf{L})$ and a set of video clips, for $\mathbf{V}$ streaming requests, find a set of paths so that the aggregate distortion of $\mathbf{V}$ concurrent video sessions is minimized. And this route selection problem can be mathematic formulated as:

- Minimize:

$$\sum_{v \in \mathbf{V})} D_v \tag{8}$$

- Subject to:

$$\rho_{ij} \le R_{ij}, \forall\{ij\} \in \mathbf{L} \tag{9}$$

$$\sum_{j:\{ij\} \in L_v} X_{ij}^v \begin{cases} = 0, & i : i \in L_v, L_v^i = \Phi \\ \le 1, & otherwise \end{cases}, \quad \forall i \in \mathbf{N}, \forall v \in \mathbf{V} \tag{10}$$

where D_v is the average distortion of received video clip v at the receive node γ_v. (10) is the rate constraint to satisfy. (11), (12), and (13) guarantee each path L_v provides a loop-free connection.

V. Conclusion

In this report, we first conclude the applications of video streaming over WMNs.

References

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