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Wireless Data Collection for Animal Monitoring System using UAV

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Abstract: One of the problems in the conservation area is the absence of network infrastructure to send files obtained from the camera trap to the data center. To build a network infrastructure in conservation area requires a large investment. One of the solution of this problems is using Delay Tolerant Network (DTN). DTN architectures can solve a problem on a challenging network that does not have a routing path. Unmanned Aerial Vehicle (UAV) is used as data carrier in order to fix this issues. In this work DTN implemented using raspberry pi with IBR-DTN framework. IBR-DTN framework is an IBR-DTN is an implementation of rfc5050 and designed for embedded Linux system. The simulation result shows that file transfer system can send file from source to destination and work properly with the average data transfer rate is 3.6 Mbps.

INTRODUCTION

Conservation as an effort to prevent the extinction of rare animals such as rhinoceros. In rhino conservation, it is difficult to detect the presence of rhinoceros in the conservation area. One way to detect the presence of a rhino is to use a camera trap. Camera will capture image and video if there is an object that crosses camera trap system.

One of the problems in the conservation area is to send the image and video files obtained from the camera trap to the data center. This is due to the absence of network infrastructure in the conservation area. Data retrieval on existing camera trap systems in the rhino conservation area is done manually. One of the solution for data transmission problem is to use the Delay Tolerant Network architecture.

Delay Tolerant Network (DTN) architecture is proposed by Fall[1]. DTN architecture aimed to unstable network that has high latency, long delay and routing path may not exist (a challenging network) such as terrestrial mobile networks, exotic media networks, military ad-hoc networks and sensor/actuator networks[1].

DTN architecture use store-carry and forward concept. It means if there is no connection available from source to destination, then source will store and carry the message until the connection available. DTN architecture has a new protocol layer called bundle layer to accommodate this concept[2]. Bundle layer lay between application layer and transport layer. Protocol layer structure on DTN can be seen on Fig. 1.

Bundle layer using persistent storage to solve problem on the network. This layer has a responsibility for reliable delivery. The messages transformed into one or more protocol data unit called "bundle" by bundle layer before they are forwarded to other nodes. Endpoint Identifiers (EIDs) are used to identify source and destination of a bundle []. DTN has custody transfer mechanism to increase delivery reliability. Custody transfer provide a retransmission mechanism if bundle fails to transmit[3].

Literature review: This section describes previous research related to delay tolerant networks for tracking wildlife.

Wildsense was proposed by Ahn *et al*.[4]. Wildsense intended to monitor spread of diseases among deer by record their movement pattern, location and interaction behavior using a collar that equipped several sensors. Wildsense use DTN to relay information between radio-based collar nodes[4].

Tovar *et al*.[5] apply DTN in wireless sensor network to monitor the current status of White Tail Deer in Ontario, Canada. The method has simulate in PlanetLab environment to evaluate it[5].

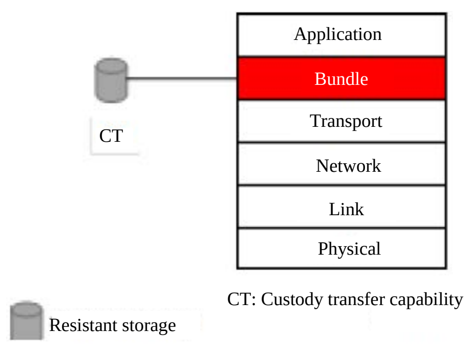

Fig. 1: DTN layers[2]

ZebraNet is designed by Juang *et al*.[6] to tracking wildlife in Kenya by tracking collars. DTN used to store and forward zebra's mobility pattern and receives information update in mobile base station.

In this work DTN implemented on raspberry pi and installed it on vehicle like Unmanned Aerial Vehicle (UAV) as data carrier to data center.

MATERIALS AND METHODS

Design and implementation: The image delivery system proposed in this work is illustrated on Fig. 2. There are three DTN nodes:

- Raspberry Pi as bundle sender (raspberry pi conservation area)
- Raspberry Pi installed on UAV as intermediate node (raspberry pi UAV)
- A computer on Data Centre as bundle receiver

For simulation system scenario, devices that use in Table 1. File transfer mechanism in this system as follows:

- Raspberry pi in conservation area receives image and video files from camera trap
- While UAV node detected, image and video files are transmitted to raspberry pi installed on UAV
- While UAV passed data centre, UAV transmit files to data centre

IBR-DTN is an implementation of rfc5050 and designed for embedded Linux system. IBR-DTN framework is used to implement this scenario because it suitable for embedded environment. IBR-DTN use IP Neighbor Discovery (IPND) to discover neighbor node. System will transmit bundles (if exist) to neighbor that discover by IPND agent[7]. IBR-DTN provides five DTN routing algorithm, i.e., direct delivery routing, static routing, flooding routing, epidemic routing and prophet

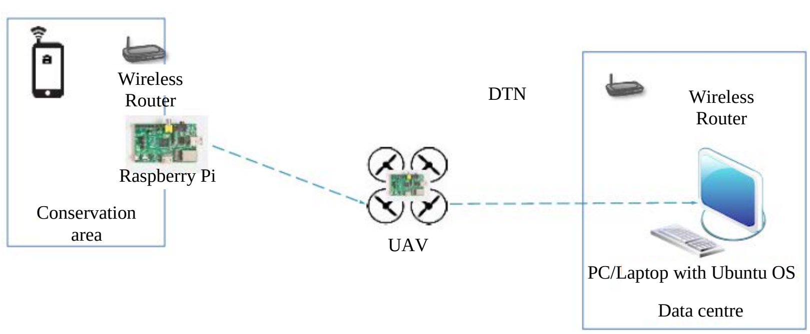

Fig. 2: DTN system scenario

Table 1: Device specification for simulation

Device	QTY	Interface
Laptop with Ubuntu OS as server on data center	1	WiFi
Raspberry pi 2 with USB WiFi	1	WiFi
Raspberry pi 1 with USB WiFi	1	WiFi
Wireless Access Point	2	

Table 2: IBR-DTN configuration setting

Parameters	Values	Notes
local_uri	1.dtn://raspberry pi 2.dtn://raspberry 1.dtn 3.dtn://pc1.dtn	EID of DTN: 1. TN node in forest 2. AV 3. PC/Laptop in data center
logfile	/var/log/ibrdtn/prophet_routing.log	The path of log file
limit_blocksize	1.3 G	Limit the block size of all bundles, default 1.3G (1G = 1.000.00 0.000 bytes)
api_port	4550	The port that daemon api to bind on
fragmentation	Yes	Yes, to enable bundle fragmentation
limit_payload	1000K	Size of bundle fragment if fragmentation enabled 1000 K (Kilobyte) = 1 Megabyte
blob_path	/home/pi/ibrdtn/blob	Define a folder for temporary storage of bundles
storage_path	/home/pi/ibrdtn/bundles	Define a folder for persistent storage of bundles in transit
storage	Simple	Defines the storage module to use, “simple” is using memory or disk (depending on storage_path)
limit_storage	350 M	Limit the size of the storage. (M = 1,000.000 bytes)
net_interfaces	Wlan0	The interface to be used by DTN protocol layer
net_lan0_type	Tcp	Use TCP as protocol listen on interface wlan0 with port 4556 (default)
net_lan0_inter	Wlan0	
facenet_lan0_port	4556	
routing	Prophet	Routing algorithm
routing_forwarding	Yes	Yes, enable routing forwarding to other nodes
time_synchronize	Yes	Yes, enable synchronize with neighbors
dht_enabled	Yes	Yes, enable the distributed Hash Table (DHT), a lookup table access for knowledge of other DTN nodes

routing. For a good delivery ratio, we use prophet routing algorithm because it has good delivery ratio compare to epidemic routing[8]. The IBR-DTN configuration setting as shown in Table 2. DTN tools that provide by IBR-DTN is used to transfer file from raspberry pi in conservation area to data center. Application using python were develop to implement this tools.

RESULTS AND DISCUSSION

The system implementation is tested by sending 100 file with size 3-6 Mega Bytes (MB). IBR-DTN API will divide file into several fragment according to the size already defined in IBR-DTN configuration file. The system will detect every new file received from the camera trap and then make the delivery process. The transmission time from raspberry pi in conservation area to UAV and UAV to data center as shown in Table 3 and 4.

Calculation of data rate is done using the data contained in Table 3. The calculation results can be seen in the Table 5 and 6.

Table 3: Transmission time test’ result from Raspberry Pi in conservation area to UAV

File size (MB)	No. of files	Total file size (MB)	Transmission time (sec)
3.1	11	34.1	118
4	10	40	127
4.1	8	32.8	84
4.3	6	25.8	76
4.4	12	52.8	132
4.5	8	36	83
4.7	10	47	129
5	11	55	123
6.1	12	73.2	136
6.2	7	43.4	73
6.3	8	50.4	95

Table 4: Transmission time test’ result from Raspberry Pi on UAV to PC in data centre

File size (MB)	No. of files sent	Total file size (MB)	Transmission time (sec)
3.10	11	34	46
4.00	10	40	102
4.10	8	33	78
4.30	6	26	62
4.40	12	53	125
4.50	8	36	82
4.70	10	47	104
5.00	11	55	117
6.10	12	73	137
6.20	7	43	153
6.30	8	50	89

Table 5: Data transfer rate result from Raspberry Pi in conservation area to UAV

File size (MB)	No. of files sent	Total file size (MB)	Data transfer rate (Mbps)
3.1	11	34.1	2.312
4	10	40	2.520
4.1	8	32.8	3.124
4.3	6	25.8	2.716
4.4	12	52.8	3.200
4.5	8	36	3.470
4.7	10	47	2.915
5	11	55	3.577
6.1	12	73.2	4.306
6.2	7	43.4	4.756
6.3	8	50.4	4.244

Table 6: Data transfer rate result from Raspberry Pi on UAV to PC in data centre

File size (MB)	No. of files sent	Total file size (MB)	Data transfer rate (Mbps)
3.10	11	34	5.9304
4.00	10	40	3.1373
4.10	8	33	3.3641
4.30	6	26	3.3290
4.40	12	53	3.3792
4.50	8	36	3.5122
4.70	10	47	3.6154
5.00	11	55	3.7607
6.10	12	73	4.2745
6.20	7	43	2.2693
6.30	8	50	4.5303

CONCLUSION

Based on simulation test, system can send file from conservation area to data center. System can detect UAV node and send file to it if there is new files detected in the system. System in data center can receive file successfully with average data transfer rate is 3.6 Mbps.

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