# Managing Theme Park Service Quality with Uninterrupted Communication

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**Abstract**: Providing theme parks safety, cleanliness, and efficiency is essential for promoting place economy and human welfare. Exhibition related spaces generally have a linear route for easy identification and access control for the whole area or for individual districts. Considering on such security, wayfinding feature, regular degree-three networks are prototyped as identity-oriented, dual-surveillance based networks fitted along the paths to enhance security and to sustain development. Moreover, reliable supervisory communication in the wireless area or application of radio frequency identification (RFID) is systematically communicated to counter the effects of an adversary's multipath radio. For any pair of bipartite nodes, spider-web networks are recognized to offer at least two mutually independent Hamiltonian paths. Their sequential-order, connectivity, and reliability in integrative area management provide the benefits of safety/security, efficient maintenance, environmental control, and human-care image due to their effective dual sensing, fault-tolerance and hamiltonian laceability.

*Keywords:* Dedicated Short Range Communication (DSRC), Integrity, Maintainability; Parallel Computing, Radio Frequency Identification (RFID)

## 1. INTRODUCTION

Theme parks are places of the mind that capture people attention in varied forms; consequently, images like safety, cleanliness, efficiency are highly emphasized [Lukas, 2008]. The inability to track objects, people, or vehicles occluded from the line-of-sight by congestion can be a concern in recreation business. Nevertheless, non-line-of-sight (water, metal) material interference can really exist in theme parks; moreover, intentional radio intrusion sources, such as personal privacy devices, are getting more attention [PNT Advisory Board, 2012; Chen et al., 2009].

Exhibition related spaces generally have a linear route for easy identification, maintainability, and access control for the whole area and even for individual districts (Fig. 1). Hence, to well support quality-assured safety and possibilities of mobile business services along paths at theme parks is proclaimed. Moreover, the wireless communication infrastructure can help customers get plenty of information for flexibly managing tasks and enjoying amenities. To promote customer satisfaction ubiquitously, coordinating bipartite networks, the spider-web or the generalized honeycomb torus networks, are proposed for establishing integrity assured platforms in thrilling but challenging theme parks.

Incorporating sensors can provide more functionality in recognition through differential sensing, comparison, and adaptation (e.g., incorporating cameras adaptively applied to accommodate environments with varying degrees of lighting). An effective, efficient sequential order for area inspection needs to be pondered especially if available resources are much limited [Knezevic, 1997]. On networking, a Hamiltonian path (cycle) is a path (cycle) linking all nodes once. Therefore, such sequentially ordered feature is essential in communication due to confidential needs in network inspection errands. Wireless communications have peer-to-peer connectivity. Hence, different mathematical performance can be assumed, inspected to help assure network reliability, and analyze the impact of communication interference confidentially.

The reliable identity based telecommunication network with parallel surveillance and adaptable detection availability is considered in the exhibitions along sequentially wayfinding concerned arterial passages (Fig.1) [Markus, 1987]. The radial-ring network is prototyped [Fig. 3] for integration of individual paths' security-communication networks, or dedicated short range communication (DSRC) networks. The degree (i.e., links to each node) of nodes for SW(m,n) is regularly optimized to three due to considerations of basic parallelism, dual-surveillance (information occlusion prevention orientation) and practicality for maintenance– e.g., regulating so only one lane in a path is used. Such parallelism can allow more security features than the traditional ring network. Individual districts for a theme park can be suitably integrally connected (e.g., via tunnel) as whole (by laceability of the proposed network) (Fig. 3). Moreover, such dual-surveillance can incorporate with allocation design on concerning availability and maintainability in changing environments (Fig. 4).

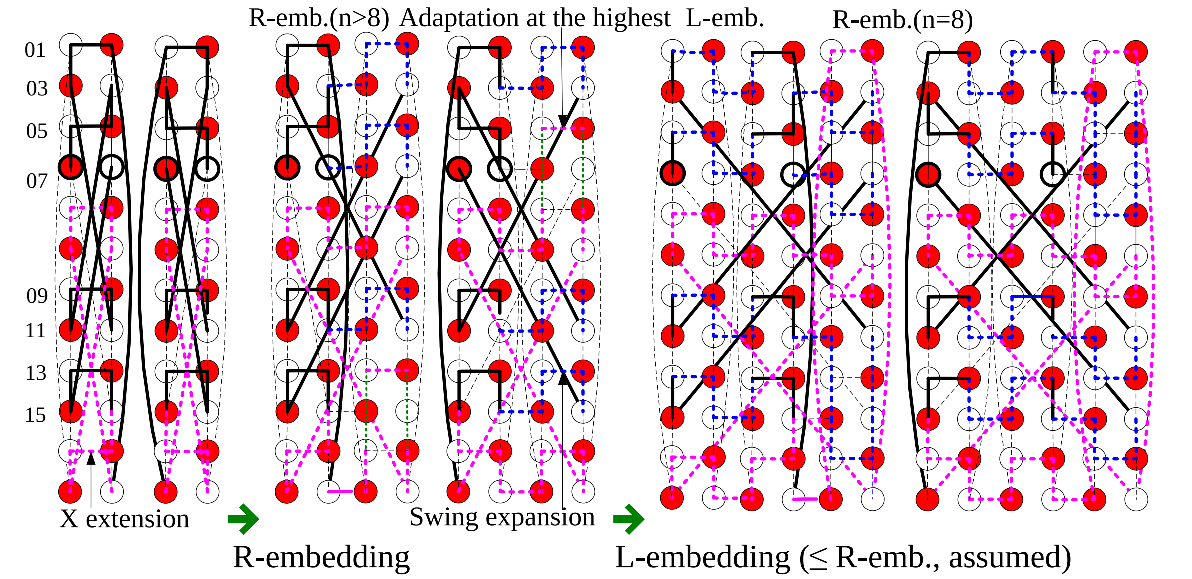
To obtain better telecommunication integrity, using correlated data analysis is rational [Damjanovski, 2005; Polak, Attfield, and Wallace, 1996]. Hence, communication transceivers or sensors allocated, networked in complementary positions are basically prototyped, probably in modular perspective- just like coordinated sensory mechanisms in two eyes', ears' promoting more diagnosing resilience, intelligence. Furthermore, such dual-surveillance can incorporate with allocation design on concerning availability and maintainability in changing environments. Wireless communication data can be better identified by comparing the difference among signals acquired through parallel sequences of location defined sensors [i.e., the performance of mutually independent Hamiltonian paths (MIHP)]. After the mathematical reviews in section 2, morphing studies on MIHP will be briefly introduced. We will explain network proposal in section 3, and then present some conclusions on application.


Fig. 1. Linear order strengthens theme parks' popularity and maintainability, (a). a theme park at Hsinchu, Taiwan, (b). a theme park at Tama, Tokyo.

## 2. MATHEMATICAL PRELIMINARIES

Communication networks are usually illustrated by graphs, in which nodes represent processors and edges represent links between processors. Let $G=(V,E)$ be a graph if $V$ is a finite set and $E$ is a subset of $\{(a,b)\ |(a,b)$ is an unordered pair of $V\}$. A path is delimited by $(x_0,x_1,x_2,\ldots x_{n-1})$. A path is called a Hamiltonian path if its nodes are distinct and span $V$. A cycle is a path of at least three nodes such that the first node is the same as the last node. A cycle is called a Hamiltonian cycle or Hamiltonian if its nodes are distinct except for the first node and the last node, and if they span $V$ [Hsu and Lin, 2008].

A bipartite graph $G = (V,E)$ is a graph such that $V=A\cup B$ and $E$ is a subset of $\{(a,b)|\ a\in A$ and $b\in B\}$; if $G\text{-}F$ remains Hamiltonian for any $F=\{a,b\}$ with $a\in A$ and $b\in B$, then $G$ is $1_p$-Hamiltonian. A graph $G$ is $1$-edge Hamiltonian if $G\text{-}e$ is Hamiltonian for any $e\in E$; moreover, if there is a Hamiltonian path between any pair of nodes $\{c,d\}$ with $c\in A$ and $d\in B$, then the bipartite graph $G$ is Hamiltonian laceable.




GHT(m,n,n/2) n≥8, m even; end nodes (x1,y1) and (x2,y2), y1=y2 even, x2-x1 odd

Proof:

Coordinates of end nodes, (0,4), (1,4), follow basic definition of GHT(m,n,n/2) in this example. Number lists are used to show that two patterns can keep mutually independent as the below; there are no collision except for end nodes.

Lt.: 07,***05,06***,04,11,***09,10***,12,03,***01,02***$_x$16,***14,13***,15,08

Rt.: 07,16,***14,13***,15$_x$***01,02***,04,11,***09,10***,12,03,***05,06***,08

The location of X extensions is shown by the subscript of x. The location of horizontal embeddings is presented with the underlines. By symmetry, assume R-emb. ≥ L-emb. The L-emb. of both patterns can increase 4 nodes at 4 location underlined per embedding; they can be considered as equivalent blocks of nodes. If n>8, (X-ext.≠0), on the R-emb., 04,11, 12,03, 15,08 of Lt. pattern and 04,11, 07,16, 12,03 of Rt. pattern have 4 nodes per embedding. If n=8, (X-ext. =0), 12,03 of Lt. pattern and 04,11 of Rt. pattern have 4 nodes more per embedding. *01,02*, of the Rt. will keep lagging if n=8; otherwise, keep leading because each X-ext. can earn nodes of multiple (8i +4, i: positive integer) of each R-emb. Nodes *05,06*, 04,11, *09,10*, 12,03 of the Lt. can keep lagging. Nodes 07,16, *14,13*, 15of the Rt. can keep lagging. Checking the first X ext. is needed only for the worst condition, and nodes of X-ext. of the Lt. keep leading.

Fig. 2. Exemplary proof of MIHP in GHT(m,n,n/2).

The number of links connecting a node is called the *degree*; a network that regularly has fewer degrees is generally economical [Stojmenovic, 1997]. For DSRC's functionality in busy traffic conditions, regular degree-3 is minimal for supporting availability, reliability, and maintainability in paths of multi-lanes; consequently, networks prototyped for DSRC are regular degree-3 based in this article.

Assume that $m$ and $n$ are positive integers, where $n$ is even and m≥2. Let $d$ be any integer such that $(m-d)$ is even. The *generalized honeycomb torus* [Cho and Hsu, 2003], $GHT(m,n,d)$ is the graph with the node set $\{(i,j)|\ 0\leq i< m,\ 0\leq j<n\}$ such that $(i,j)$ and $(k,l)$ are adjacent if they satisfy one of the following conditions: (1) $i=k$ and $j=l\pm1(\mathbf{mod}\ n)$; (2) $j=l$ and $k=i-1$ if $i+j$ is even; and (3) $i=0$, $k=m-1$, and $l=j+d(\mathbf{mod}\ n)$ if $j$ is even.

The spider-web network, $SW(m,n)$ is a graph with the node set $\{(i,j)|\ 0\leq i<m,\ 0\leq j<n\}$, where $m,\ n\geq 4$ even integers, such that $(i,j)$ and $(k,l)$ are adjacent if they satisfy one of the following conditions: (1) $i=k$ and $j=l\pm1$; (2) $j=l$ and $k=i+1(\mathbf{mod}\ m)$ if $i+j$ is odd or $j=n-1$; and (3) $j=l$, $k=i-1(\mathbf{mod}\ m)$ if $i+j$ is even or $j=0$. The configuration of $SW(m,n)$ is shown in Fig. 3.

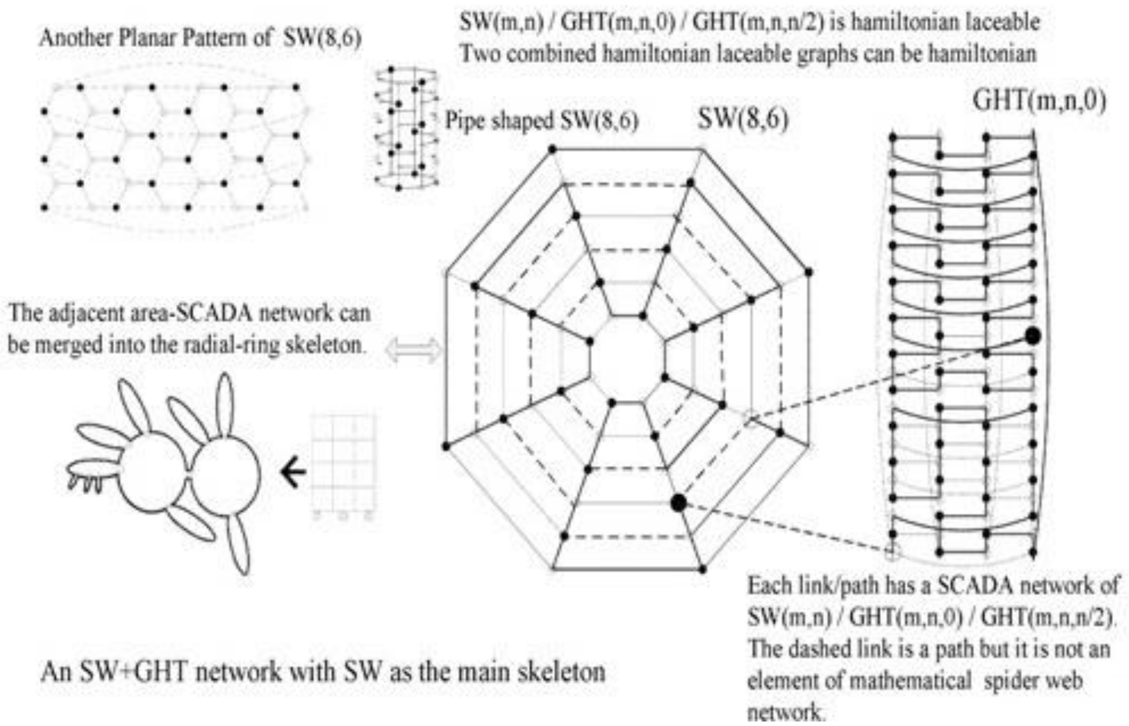



Fig. 3. Integration of the SW network for an area SCADA network with hamiltonian laceability (Hsu 2008a).

It is proved that SW(m,n) is *1-edge Hamiltonian* and $1_p$-Hamiltonian [Kao and Hsu, 2005a]. Similarly, GHT(m,n,0), also named $HReT(m,n)$, is *1-edge Hamiltonian* if $n\geq4$; $1_p$-Hamiltonian if $n\geq6$ or $m=2$, $n\geq4$ [Cho and Hsu, 2002]. When $m$ and $n$ are positive integers with $n$, $m$-$n/2$ being even, $GHT(m,n,n/2)$ is proved *1-edge Hamiltonian* if $n\geq4$; $1_p$-Hamiltonian if $n\geq6$ or $m=2$, $n\geq4$ [Hsu et al., 2010]. Thus, the fault-tolerance in which we are engaged is systematically based. Moreover, $GHT(m,n,0)$ , $GHT(m,n,n/2)$, and $SW(m,n)$ are *Hamiltonian laceable* if $m,n\geq4$ integers [Kao and Hsu, 2005b; Hsu, Lin and Kao, 2008].

Two Hamiltonian paths $P_1=(u_1,\ u_2,\ldots,u_{n(G)})$ and $P_2=(v_1,v_2,\ldots,v_{n(G)})$ of $G$ from $u$ to $v$ are independent if $u=u_1=v_1$, $v=u_{n(G)}=v_{n(G)}$, and $u_i\neq v_i$, for every $1<i<n(G)$. A set of Hamiltonian paths, $\{P_1,P_2,\ldots,P_k\}$, of $G$ from $u$ to $v$ is *mutually independent* if any two different *Hamiltonian paths* are independent from $u$ to $v$. The mechanism of

*mutually independent Hamiltonian paths (MIHP)* can be applied to parallel processing [Teng et al., 2006]. Such a feature is also considered for secret communications [Lee et al., 2005; Hsu, 2009]. It is proved that SW(m,n) has MIHP performance [Hsu, 2012]; and it is believed that GHT(m,n,0) and GHT(m,n,n/2) can have such performance if nodes are more than 16 (Fig. 2).

## 3. NETWORK PROPOSAL

By inherent, real radial-ring motion flow, a grid urban pattern can enlarge its original scope of urban activities. In this perspective, a grid pattern can rationally be adapted to a radial-ring pattern; moreover, the grid can be illustrated to be the radial-ring (Keeble, 1969). It is found that bipartite spider-web networks have mathematical laceability (Fig. 3) to sustain the ring performance of connected spider-web networks.

The proposed radial-ring configured DSRC network prototype is made of spider-web networks; in other words, it can be a spider-web (radial-ring) network of spider-web (radial-ring) networks. Furthermore, just as cities may be multi-centered, flexible amount of radial-rings of radial rings can be composed or sub-divided (e.g., in a campus site, a large vehicle architecture); i.e., fractal. Such connected rings can have sequential order, fault-tolerance for maintenance, and fractal features for hierarchical management.

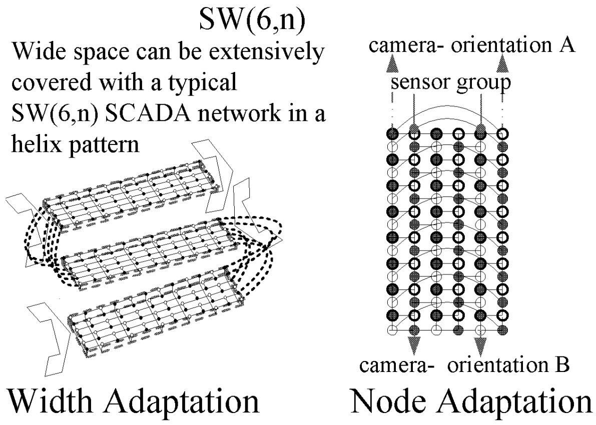



Fig. 4. Network adaptation

In another perspective, available land resources may be restricted by natural or practical conditions. Except for adopting underground or overpass construction technologies, such restrictions can be more carefully dealt with, or preserved if the proposed information network prototype can be applied to prevent adversary effects on traffic flows and spatial development - i.e., proposed information networks can be well connected via underground, overpass or public paths to help traffic well moved.

Parallelism along paths is aimed to analyze spatial-tempo interference. Moreover, the system manager may use such parallelism for operating dynamic authentication/authorization in transporting privacy demanded tasks, which are recorded through active RFID (radio frequency identification) system. This paper proposes a network in which the sequence of such orderly operation can be both flexibly and logically adjusted in a Hamiltonian way, because the network has scalability and Hamiltonian laceability. Hence, the aforementioned, highly reliable security-information networks can offer continuous and thoughtful protection for tourists / travelers.

## 4. CONCLUSION

In this paper, dual-surveillance-based information-security networks with RFID application are modeled to be spatially integrated within the linear wayfinding-based circulation pattern. Network information transmission is studied to establish MIHP performance to cope with occlusion, radio interference, and multipath effects.

Three mechanisms of dual-surveillance based supervisory control and data acquisition (SCADA) network prototypes are aimed to provide (1) better functionality, just as human beings can have better vision with two eyes instead of one; (2) more fault-tolerance in both nodes and links than the single node or ring network for real-time facility management; and (3) the capability to execute efficient and effective checking or maintenance of a SCADA network in a systematically sequential order environment.

Hamiltonian laceability can help flexibly integrate individual information-security networks along paths. Such networks can be adapted, then they can have the mathematical performance of a spider-web; i.e., offering response capabilities even after two paths of that integrated network have been seriously compromised.

The application of RFID can naturally be considered in theme parks by means of information-security network. It requires routine, maintenance, auditing, and accounting, preferably by different authorities. Through the high trustworthiness of such information-security networks, the exhibition host may be encouraged to use scattered lots for an attractive yet integrated operation management.

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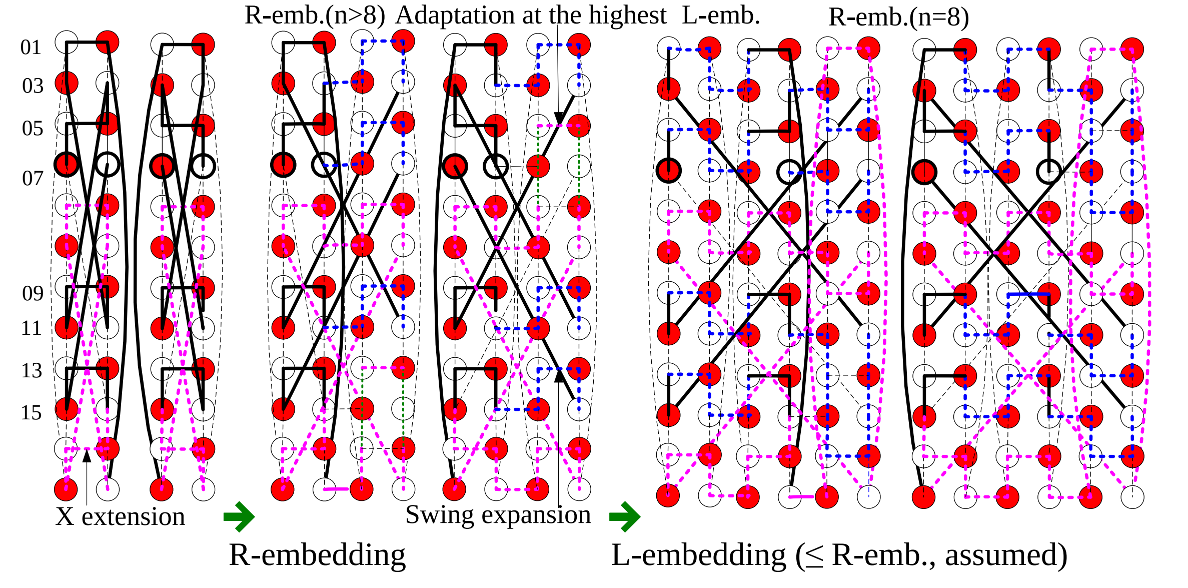


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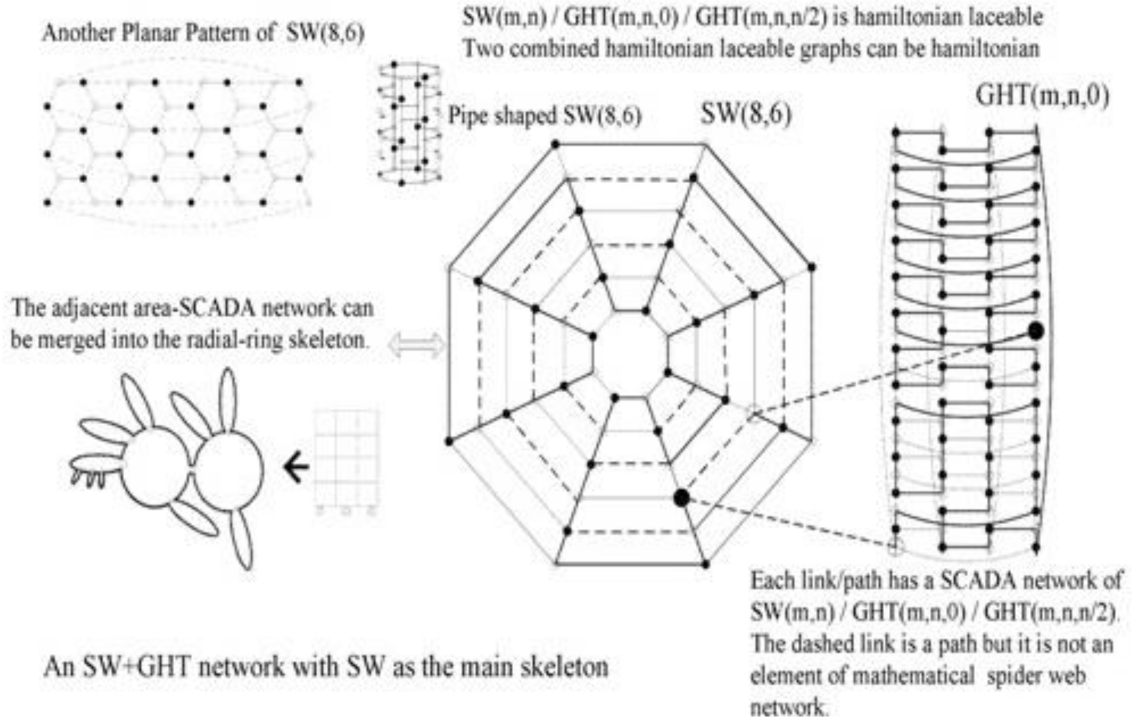


Fig. 3. Integration of the SW network for an area SCADA network with hamiltonian laceability (Hsu 2008a).

It is proved that GHT(m,n,0), also named *HReT(m,n)*, is *1-edge Hamiltonian* if $n \geq 4$; $1_p$-Hamiltonian if $n \geq 6$ or $m=2$, $n \geq 4$ [Cho and Hsu, 2002]. When *m* and *n* are positive integers with *n*, $m\text{-}n/2$ being even, *GHT(m,n,n/2)* is proved *1-edge Hamiltonian* if $n \geq 4$; $1_p$-Hamiltonian if $n \geq 6$ or $m=2$, $n \geq 4$ [Hsu et al., 2010]. Thus, the fault-tolerance in which we are engaged is systematically based. Moreover, *GHT(m,n,0)* , *GHT(m,n,n/2)*, and *SW(m,n)* are *Hamiltonian laceable* if $m,n \geq 4$ integers [Kao and Hsu, 2005b; Hsu, Lin and Kao, 2008].

Two Hamiltonian paths $P_1=(u_1, u_2, \ldots, u_{n(G)})$ and $P_2=(v_1, v_2, \ldots, v_{n(G)})$ of *G* from *u* to *v* are independent if $u=u_1=v_1$, $v=u_{n(G)}= v_{n(G)}$, and $u_i \neq v_i$, for every $1<i<n(G)$. A set of Hamiltonian paths, $\{P_1, P_2, \ldots, P_k\}$, of *G* from *u* to *v* is *mutually independent* if any two different *Hamiltonian paths* are independent from *u* to *v*. The mechanism of *mutually independent Hamiltonian paths (MIHP)* can be applied to parallel

processing [Teng et al., 2006]. Such a feature is also considered for secret communications [Lee et al., 2005; Hsu, 2009]. It is proved that SW(m,n) has MIHP performance [Hsu, 2012]; and it is believed that GHT(m,n,0) and GHT(m,n,n/2) can have such performance if nodes are more than 16 (Fig. 2).

## 3. NETWORK PROPOSAL

By inherent, real radial-ring motion flow, a grid urban pattern can enlarge its original scope of urban activities. In this perspective, a grid pattern can rationally be adapted to a radial-ring pattern; moreover, the grid can be illustrated to be the radial-ring (Keeble, 1969). It is found that bipartite spider-web networks have mathematical laceability (Fig. 3) to sustain the ring performance of connected spider-web networks.

The proposed radial-ring configured DSRC network prototype is made of spider-web networks; in other words, it can be a spider-web (radial-ring) network of spider-web (radial-ring) networks. Furthermore, just as cities may be multi-centered, flexible amount of radial-rings of radial rings can be composed or sub-divided (e.g., in a campus site, a large vehicle architecture); i.e., fractal. Such connected rings can have sequential order, fault-tolerance for maintenance, and fractal features for hierarchical management.

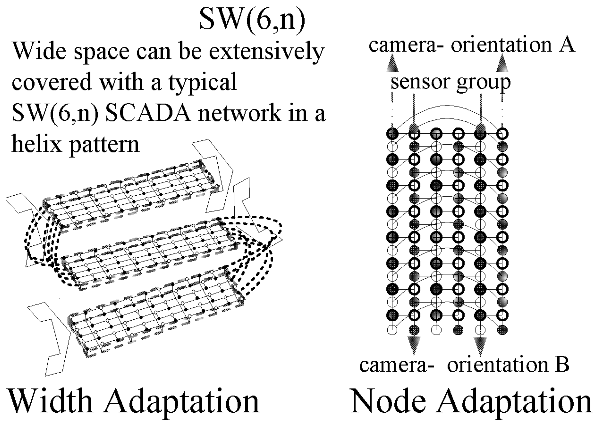


Fig. 4. Network adaptation

In another perspective, available land resources may be restricted by natural or practical conditions. Except for adopting underground or overpass construction technologies, such restrictions can be more carefully dealt with, or preserved if the proposed information network prototype can be applied to prevent adversary effects on traffic flows and spatial development - i.e., proposed information networks can be well connected via underground, overpass or public paths to help traffic well moved.

Parallelism along paths is aimed to analyze spatial-tempo interference. Moreover, the system manager may use such parallelism for operating dynamic authentication/authorization in transporting privacy demanded tasks, which are recorded through active RFID (radio frequency identification) system. This paper proposes a network in which the sequence of such orderly operation can be both flexiblly and logically adjusted in a Hamiltonian way, because the network has scalability and Hamiltonian laceability. Hence, the aforementioned, highly reliable security-information networks can offer continuous and thoughtful protection for tourists / travelers.

## 4. CONCLUSION

Three mechanisms of dual-surveillance based supervisory control and data acquisition (SCADA) network prototypes are aimed to provide (1) better functionality, just as human beings can have better vision with two eyes instead of one; (2) more fault-tolerance in both nodes and links than the single node or ring network for real-time facility management; and (3) the capability to execute efficient and effective checking or maintenance of a SCADA network in a systematically sequential order environment.

Hamiltonian laceability can help flexibly integrate individual information-security networks along paths. Such networks can be adapted, then they can have the mathematical performance of a spider-web; i.e., offering response capabilities even after two paths of that integrated network have been seriously compromised.

which The application of RFID can naturally be considered in theme parks by means of information-security network. It requires routine, maintenance, auditing, and accounting, preferably by different authorities. Through the high trustworthiness of such information-security networks, the exhibition host may be encouraged to use scattered lots for an attractive yet integrated operation management.

In this paper, dual-surveillance-based information-security networks with RFID application are modeled to be spatially integrated within the linear wayfinding-based circulation pattern. Network information transmission is studied to establish MIHP performance to cope with occlusion, radio interference, and multipath effects.

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