



Title	Spatial Distribution of New Growing ICT Service Industry in Mandalay City
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Abstract

This paper examines the spatial distribution and temporal development of ICT businesses, new growing services industries oriented into the central area in relation to the CBD expansion of Mandalay City. The spatial distribution pattern of ICT business centers are analyzed by using ArcGIS 9.3. This type of industry was a new industry appearing for the first time in 1987. The increase after the late 1990s was particularly dramatic, and corresponded to the economic liberalization of Myanmar. ICT service centers were characterized by concentration into the central commercial area, with some differences among types. However, there were few centers in the core CBD. The geometric centers of distribution of the ICT service establishments were located not at the core CBD, but south of the railway station. This finding suggested that the locations of ICT service centers correspond to the expansion of the central commercial area. It can be said that the service centers played a role in expanding the CBD.

Key words: ICT service industry, CBD, economic liberalization, geometric centers

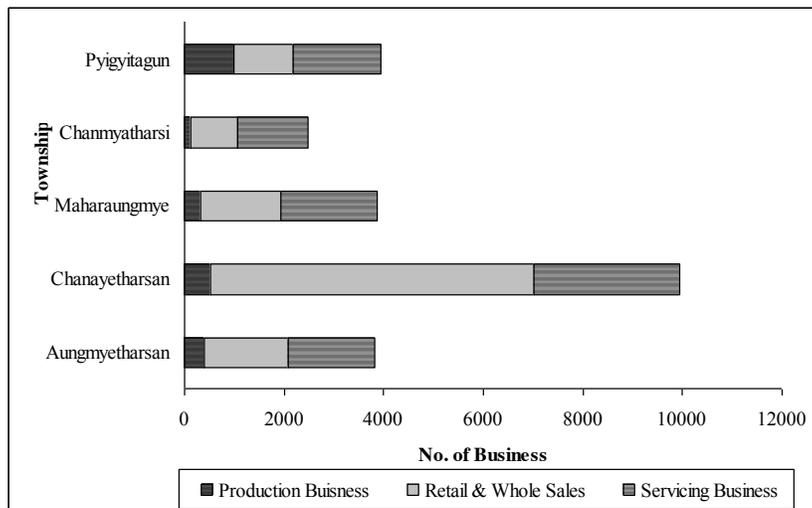
I. Introduction

This paper examines the process of expansion of the central commercial area through analyzing the locations of the information and communication technology services industry (ICTSI). The ICTSI consists of the following six businesses: computer training centers (CTC), computer and accessories sales centers (CASC), computer repair service centers (CRSC), desktop publishing centers (DTPC), internet access centers (IAC), and software development centers (SDC). These business establishments emerged for the first time in the central area of Mandalay in the late 1980s when the economic liberalization policies were implemented. After that time, the number of these establishments rapidly increased and their spatial distribution spread over time. In Mandalay city, there were 24,044 businesses establishments in 2008 according to the Mandalay Directory (Table 1, Fig. 1). The largest number of businesses were retail and wholesale businesses at 11,910, about 50% of the total number of establishments. There were also a large number of service businesses at 9,770, or about 41% of the total businesses. There were two types of service businesses, those for personal consumption, and those for business. ICT service businesses are generally classified into the latter. The importance of business services based on ICT has been increasing dramatically since the commercialization of internet and mobile technologies. The number of establishments of production businesses was 2,364, and its share was about 9 % of total establishments.

Table 1 Business Number of Each Township in Mandalay City (2008)

Township	No. of Business	Percentage
Aungmyetharsan	3807	15.8
Chanayetharsan	9953	41.4
Maharaungmye	3874	16.1
Chanmyatharsi	2474	10.3
Pyigyitagun	3936	16.4
Total	24044	100.0

Source: Mandalay City Development Committee (Mandalay Directory Group)



Source: Mandalay City Development Committee (Mandalay Directory Group)

Fig. 1 Type of business and the corresponding number of each township of Mandalay City

About 41% of the establishments are concentrated into the central township, Chanmyatharsi (Fig. 1). Especially in the case of retail and wholesale businesses, the concentration in the central township was remarkably high, about 45%. In service businesses the concentration rate was relatively low. The share of businesses established in Chanmyatharsi was only 30%. However, if the concentration rate was calculated separately for the two types of personal service and business services, the latter is high. On the other hand, Pyigyitagun had the largest share of production businesses (manufacturing) among the five townships. In this township, as mentioned in chapter three, there is a large new industrial zone constructed during the early 1990s, which a lot of small factories relocated to from the inner area.

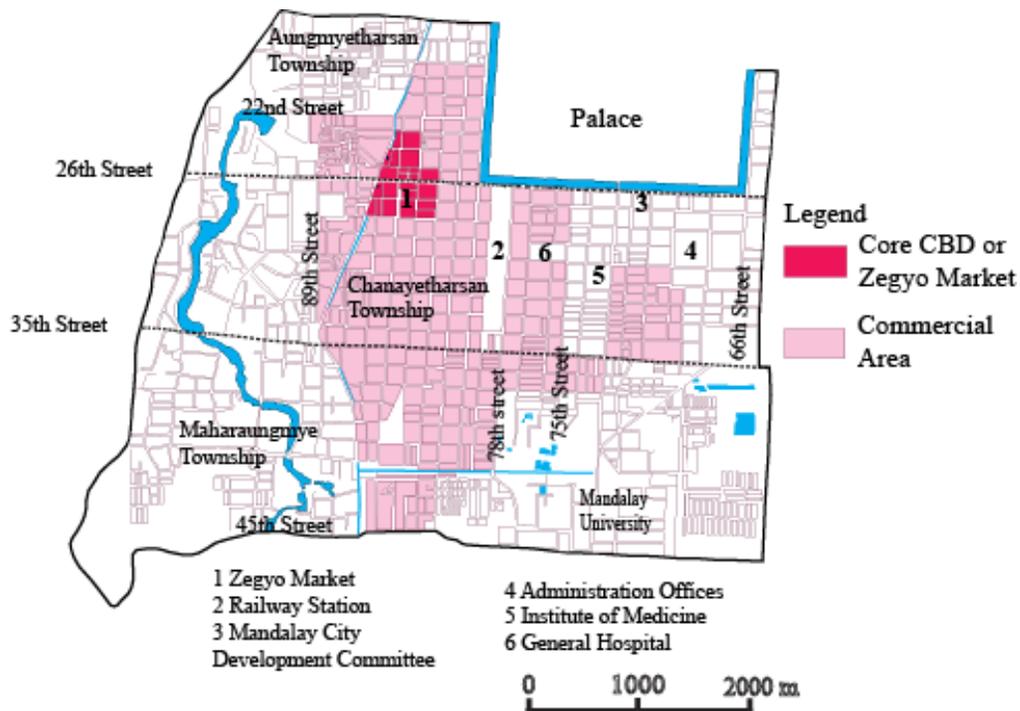
II. Overview of Central Business District (CBD)

Fig. 2 shows a street plan and land use of CBD of Mandalay. The red colored district in the figure indicates the core CBD, whose representative facility is Zegyo Market. This market was founded in 1903. It remains the largest market in Mandalay, and its function is wholesaling (Plate 1). This area is the most congested area in Mandalay, and all local bus lines run through it. No. 2 in the figure shows the railway station, which was constructed as the gateway to Upper Myanmar by the British after 1904 (Plate 2). In Mandalay, we can divide the southern area of the Palace into eastern and western parts. The eastern part was designated as a public area for administrative offices (No. 3, No. 4, educational institutions (No. 5), and other public facilities

including hospitals (No. 6). The ward in which the institute of medicine (No. 5) is located is classified into a non-commercial area. Since this ward includes several types of educational institutes such as a primary school, a high school and monasteries, it is excluded from the commercial area in spite of the existence of shops along the streets.

The west part of the railway station was set up as residents for local people, a market area and monasteries. Mandalay University was established in 1925 in the south of the city area on land that was paddy field before the university was constructed. Thus, the campus was on the fringe of the city in the 1920s.

There are three main east-west streets and three north-south streets in the CBD. The former includes 26th street, 30th street and 35th street. The latter consist of 78th street, 80th street and 84th street. The 78th street is the national highway which connects Mandalay with other cities in the south, including Yangon. The front gate of the railway station faces 30th street. There are now large markets and large banks along 78th street south of the station. In addition, main accommodation facilities such as hotels are concentrated in the CBD.



Source: Nwe Ni Hlaing, 1999, p-34

Fig. 2 Location of CBD and commercial area



Zegyo Market (Core CBD Area)
Plate 1. Zegyo Market, the most congested area of Mandalay City



Railway Station
Plate 2 Railway Station, the gateway of Upper Myanmar.

III. Methodology and data

We confirmed the locations of ICT service establishments as follows: Data before 2000 were collected by field and questionnaire surveys conducted in 1999 (Tin Moe Lwin, 2000). In that survey, we chose all ICT centers with signboards in front of their center and used the information obtained from the Mandalay City Development Committee. Data after 2000 were based on the Mandalay Business Directory issued by this Committee. This directory has been published every year since 1996.

We also prepared a city map using GIS software to draw the distribution of ICT centers and analyzed spatial center, standard distance and standard deviational ellipse of ICT centers. First we obtained a base map from the Mandalay City Development Committee. Then we drew a city map that included fundamental information such as streets, administrative boundaries, parcels, and addresses. In addition, we discriminated commercial areas by the following measure. The wards where the ratio of the commercial area to the total area was five or more were defined as a commercial area (Fig. 2, Nwe Ni Hlaing, 1999). The area mainly extends between 22nd and 45th street from north to south and between 75th and 89th street in the east-west direction. This area covers about 3.2 sq miles, and includes the major proportion of commercial and service functions of Mandalay City and such principal nodes in the transportation network as Mandalay Railway Station, and bus pools. In this area, almost all residential buildings along all streets are shop houses in which the ground floor or upper floor are used for a variety of commercial or service functions (Plates 3). Furthermore, in the case of West Chanayethazan and Central Chanayethazan, the above commercial area ratios were distinctly high, 54 percent and 23 percent, respectively. Moreover, West Pyigyikyethaye ward in Aungmyetharsan township was 15.1 percent (Nwe Ni Hlaing, 1999). They were also the old commercial areas in which Zegyo Market was located. Therefore, the area of the three wards could be discriminated as the core CBD.

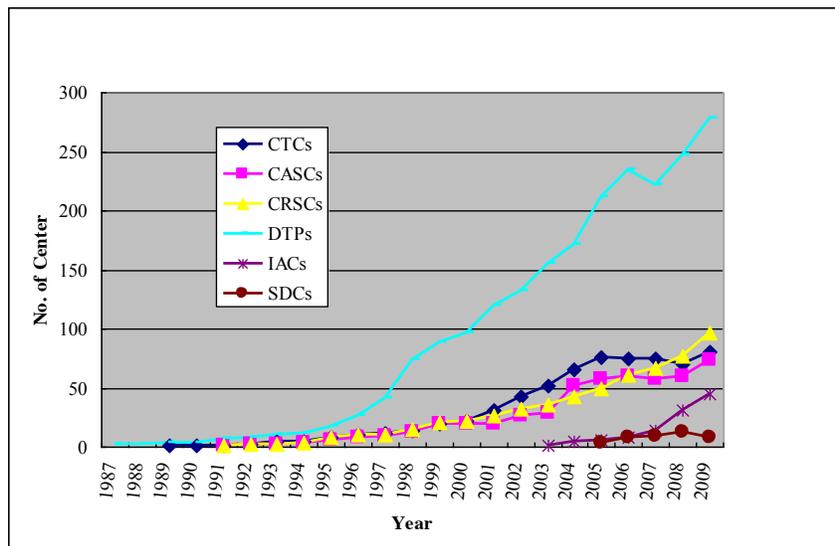
Other than the central area, there are small three commercial areas in Aungmyetharsan, Chanmyatharsi, and Pyigyitagun. Each is a market area.



Plates 3. Residential buildings along main street, ground floor are used for economic activities and upper floor for living

IV. Development of ICT service centers in Mandalay City

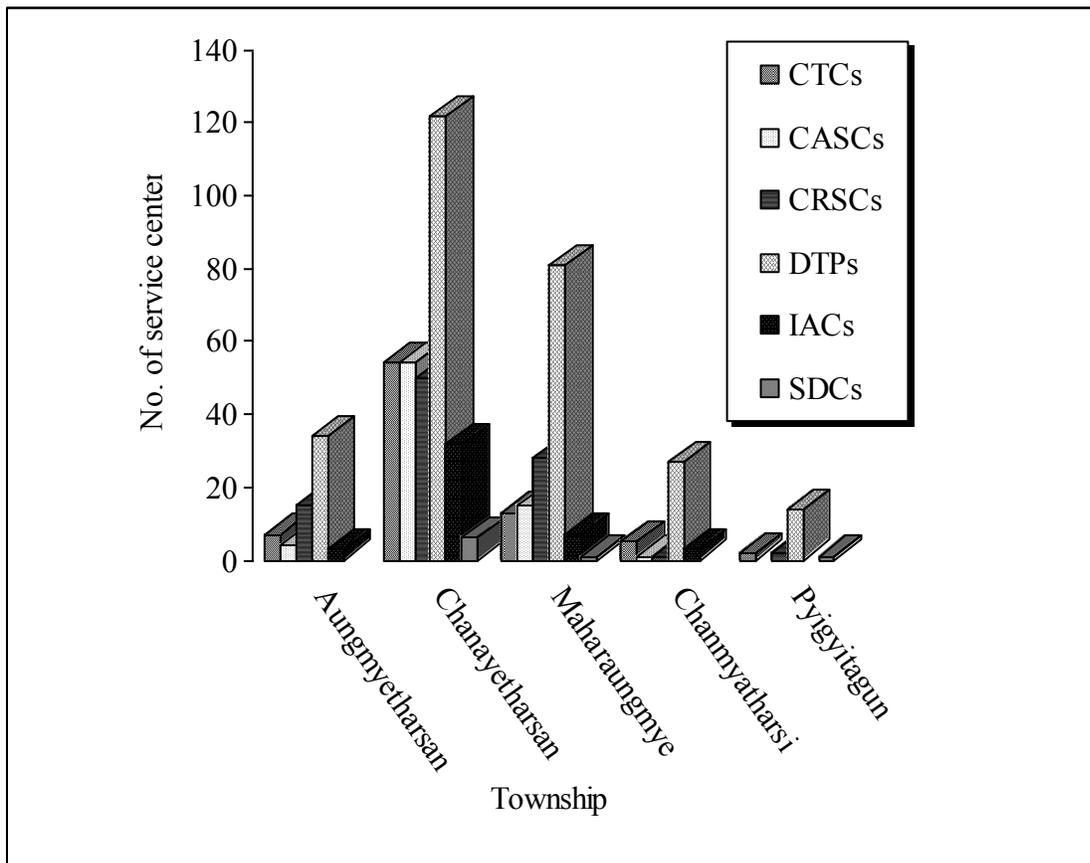
Fig. 3 shows the number of all ICT centers by year and township. According to the table, the rapid increase of centers started in the late 1990s, and accelerated in the 2000's.



Sources: Field Surveys and Mandalay Directories

Fig. 3 Yearly development of all ICT services in Mandalay City

On the other hand, ICT service centers are highly market oriented and located in places with easy access to customers. As a result, the majority of ICT service centers are located in CBD, Chanayetharsan township or in neighboring areas (Fig. 4). In addition, these service centers are also concentrated in the vicinity of Mandalay University in the southwest of CBD. Hereafter, the transition of the increase of centers and the change in their distribution are examined by type of center.



Sources: Field Surveys and Mandalay Directories

Fig. 4 The concentration of ICT service center by township in 2009

1. Computer Training Center (CTC)

Computer training centers (CTC) are becoming increasingly important with the rapid technological innovation now occurring. In Mandalay, the first CTC was opened at the YMCA on 26th street, in Seidaramahi Ward, near the Mandalay City Development Committee (Fig. 5) in

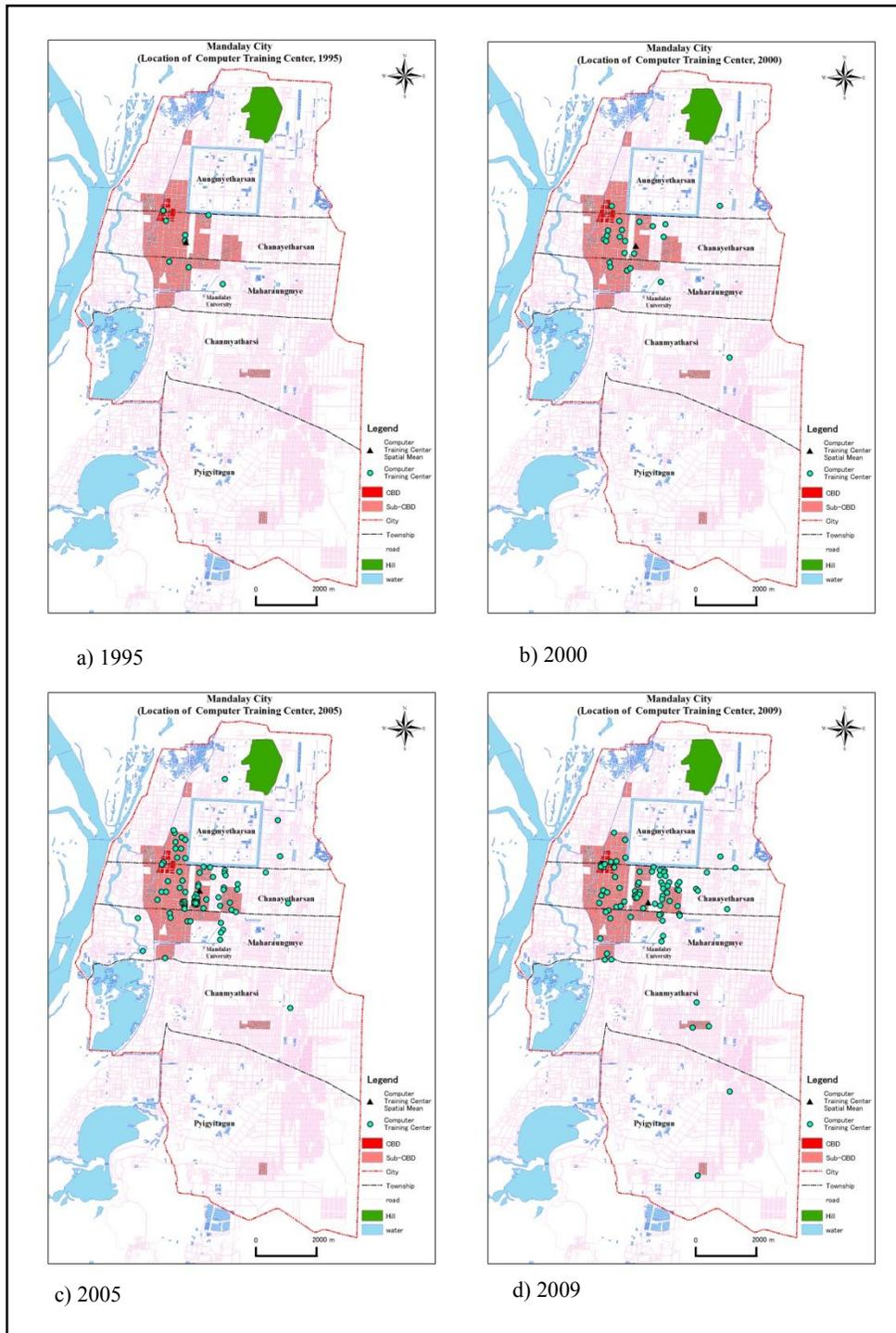
Chanayetharsan township in 1989. There were no additional CTCs opened in 1990 and 1991.

Table 2 Development of Computer Training Center within each Township

Year	Township					Total
	Aungmy etharsan	Chanaye tharsan	Maharaung mye	Chanmya tharsi	Pyigyitagun	
1989		1				1
1990		1				1
1991		1				1
1992		2				2
1993	1	2	2			5
1994	1	2	2			5
1995	1	4	3			8
1996	1	5	4			10
1997	1	7	4			12
1998	1	9	4			14
1999	1	14	4			19
2000	2	14	5	1		22
2001	4	20	6	1		31
2002	8	27	7	1		43
2003	10	30	11	1		52
2004	10	46	9	1		66
2005	13	51	11	1		76
2006	16	46	11	1	1	75
2007	16	46	11	1	1	75
2008	9	45	10	4	2	70
2009	7	54	13	5	2	81
Percentage	8.6	66.7	16	6.2	2.5	100

Sources: Field Surveys and Mandalay Directories

Retardation was due to little use of computer services by people and people were still unaware of the capability of computers. With the deepening of market-oriented economic policies of the government, there was a demand for services based on ICT. With government encouragement, computers and related accessories were imported, and additional CTCs were opened. In 1992, the “Ava” CTC was opened on the first floor of Zegyo Market, which is located in the core Central Business District (CBD) of Mandalay. The famous computer training school, KMD, was established in 1994, near Mandalay University. The changes in the number of CTCs within each township during the 1989-2009 periods are shown in Table 2. Since the spread of information technology has accelerated, CTCs are expected to increase in number in the years to come.



Sources: Field Surveys and Mandalay Directories

Fig. 5 The temporal distribution pattern of CTCs compared with CBD.

Table 2 shows that the number of CTCs has increased mainly in Chanayetharsan township. The increases in CTCs vary slightly in other areas, and their number has actually declined in Aungmyetharsan township, from 16 centers in 2007 to 7 centers in 2009. This spatial change in CTCs reflects the concentration of ICT service centers in CBD.

In Mandalay, there were a total of 81 CTCs in 2009: 54 in CATS, 13 in MHAM, 7 in AMTS, 5 in CMTS, and 2 in PGTG. Out of these CTCs, 64.2 % are located in the central commercial area on easily accessible streets (Fig. 5). Furthermore, a large number of CTCs were located around railway stations and government administration offices. The number of CTCs located in the core CBD was small. We believe there were two reasons for this. One is that a lot of space is needed in this type of center for teaching. The other is that the rent is too high in the core CBD.

2. Computer and Accessories Sales Center (CASC)

In Mandalay City, the first CASC was opened in Chanmyatharsi North Ward in MHAM township in 1991. It was named the “CEM” CASC. The center was located at the southern edge of the CBD of Mandalay, and was a tenant of a shop house. In 1992, a CASC named “Winner” was opened in Pyigyikyethaye Ward in AMTS township. There were no new centers opened in 1993 (Table 3). Beginning in 1994, the CASCs began to increase. In 2004, the number of CASCs rapidly increased from 29 to 52. All of the new centers in 2004 were located in the central area of Chanayetharsan township. These centers have similar characteristics as other retail shops selling luxury goods. Many customers visit these establishments to purchase computers. Thus, it is important for such shops to be accessible. As a result, they tend to be located in sites with good accessibility, such as the central CBD (Plates 6).

In 2009, there were 74 CASCs in Mandalay City, including 54 centers in CATS township, 15 centers in MHAM township, 4 centers in AMTS township, and 1 center in CMTS township, respectively. There is no center in PGTG township, which is located on the fringes of Mandalay City. Out of the 74 CASCs, 85% lie in the CBD of Mandalay City. The spatial temporal distribution pattern and increasing number of CASCs is shown in Fig. 6. CATS and MHAM townships are located in the central part of Mandalay City, which are served by various transportation terminals. Thus, these townships have favorable conditions for attracting customers from other regions in addition to those within the city and neighboring areas. The CASCs located in other townships such as AMTS mainly serve the demand from the local and

surrounding areas. Therefore, the number of CASCs is expected to increase in the CBD area of Mandalay City.

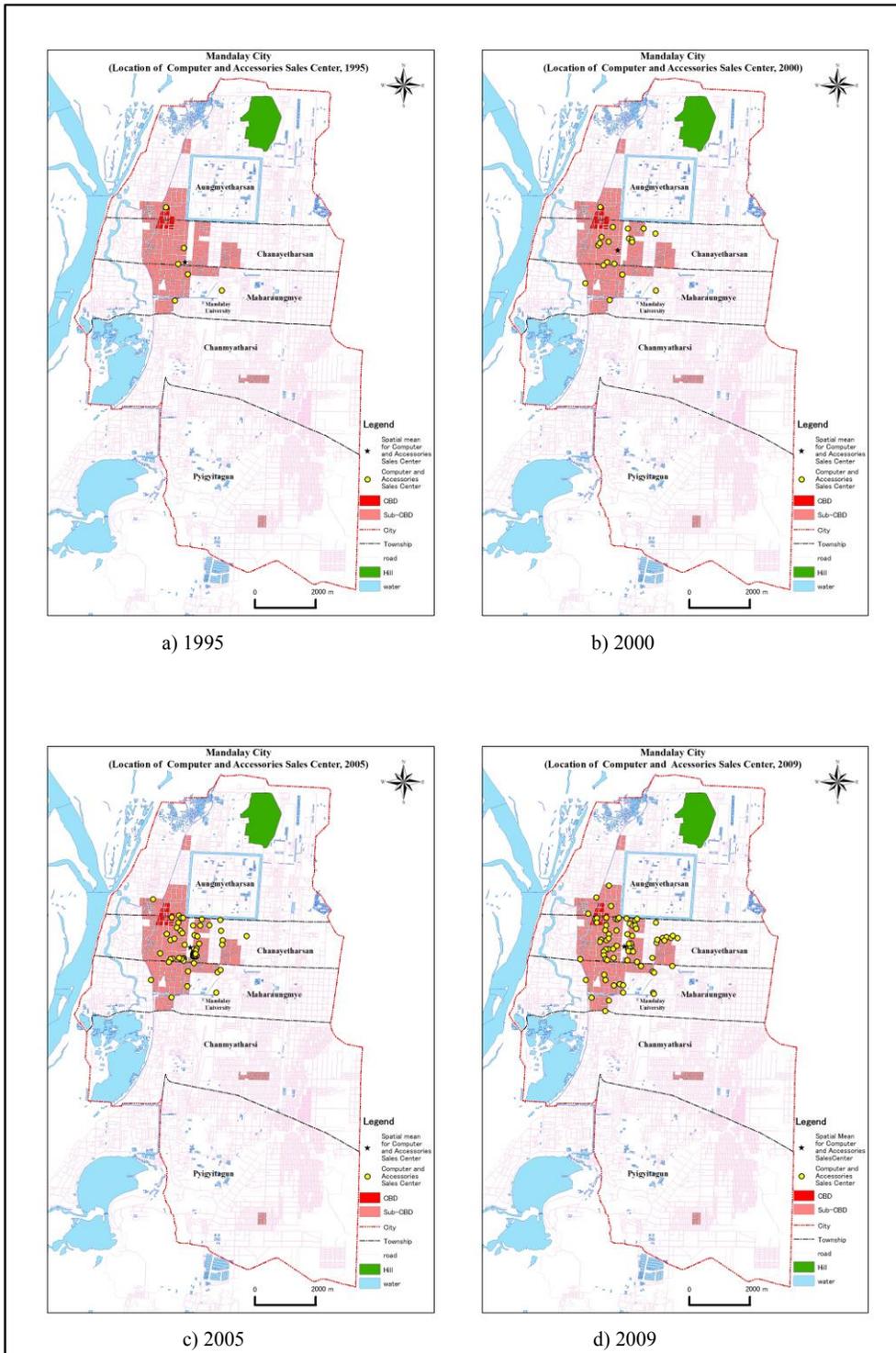
Table 3 Development of computer & accessories sales center within each Township

Year	Township					Total
	Aungmye tharsan	Chanaye tharsan	Maharaung mye	Chanmya tharsi	Pyigyitagun	
1991			1			1
1992	1		1			2
1993	1		1			2
1994	1		2			3
1995	1	2	3			6
1996	1	3	4			8
1997	1	4	4			9
1998	1	8	4			13
1999	1	13	5			19
2000	1	13	5			19
2001	1	16	3			20
2002	1	21	4			26
2003	1	22	6			29
2004	1	42	9			52
2005	2	47	9			58
2006	4	45	11			60
2007	2	45	11			58
2008	2	48	9	1		60
2009	4	54	15	1		74
Percentage	5.4	73	20.3	1.3		100

Sources: Field Surveys and Mandalay Directories



Plates 6 One of computer and accessories sales centers near Zeygyo Market



Sources: Field Surveys and Mandalay Directories

Fig. 6. The spatial and temporal distribution pattern of CASCs compared with CBD.

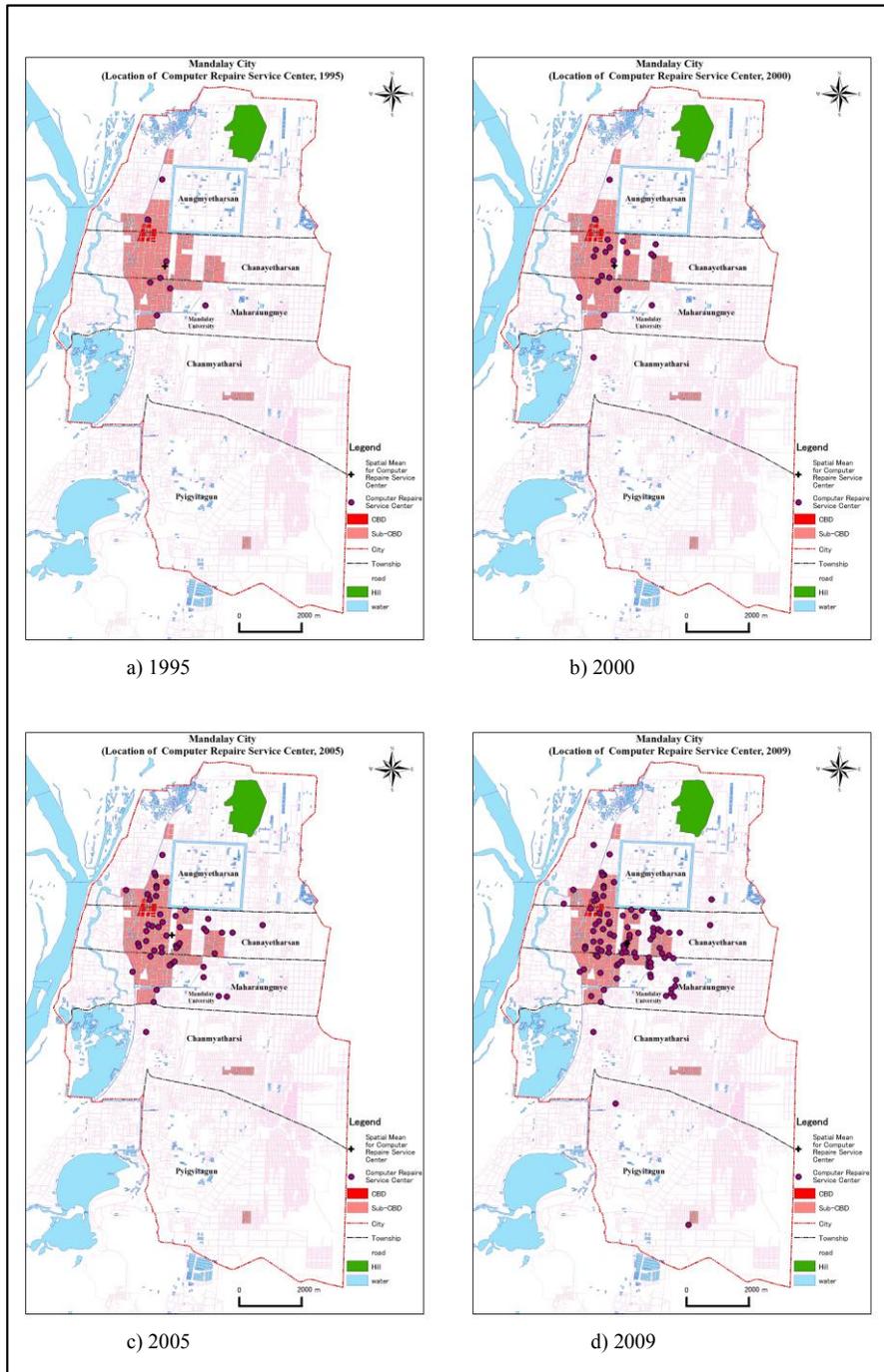
3. Computer Repair Service Centers (CRSC)

In Mandalay, the first CRSC opened in 1991, and was attached to the center named the “CEM” Center located in Chanmyatharsi North in MHAM township. Although this first center was located in Chanmyatharsi North ward, outside of the CBD, it was easily accessible from other areas because it was located along the main north-south road. After that, the distribution pattern of CRSCs was similar to that of CTCs and CASCs (Fig. 7). The yearly development of CRSCs in Mandalay since 1991 is shown in Table 4. The development became remarkable from the end of the 1990s.

Table 4 Development of computer repair service center within each Township

Year	Township					Total
	Aungmye tharsan	Chanaye tharsan	Maharaung mye	Chanmy atharsi	Pyigyitagun	
1991			1			1
1992	1		1			2
1993	1		1			2
1994	1		3			4
1995	2	2	4			8
1996	2	3	5			10
1997	2	3	5			10
1998	2	8	5			15
1999	2	13	6			21
2000	2	13	6	1		22
2001	3	17	6	1		27
2002	5	18	8	1		32
2003	8	18	9	1		36
2004	8	22	11	1		42
2005	10	27	11	1		49
2006	11	31	17	1	1	61
2007	12	33	19	1	2	67
2008	14	40	20	1	2	77
2009	15	50	28	1	2	96
Percentage	15.6	52.1	29.2	1	2.1	100

Sources: Field Surveys and Mandalay Directories



Sources: Field Surveys and Mandalay Directories
 Fig. 7. The spatial and temporal distribution pattern of CRSCs compared with CBD.

In 2009, there were 96 CRSCs in Mandalay City (Table 4), including 15 centers in AMTS, 50 centers in CATS, 28 centers in MHAM, 1 center in CMTS, and 2 centers in PGTG, respectively. Out of 96 CRSCs, 71.9% belonged to the central commercial area of Mandalay

City. The concentration ratio of the CRSCs into the central commercial area was higher than the concentration ratio of the CTCs, and lower than the ratio of CASCs. In the case of CASC, there were no centers located outside of the central commercial area, while there were several CRSC centers located outside of the CBD.

4. Desktop Publishing Centers (DTPC)

Desktop publishing refers to the process of producing documents such as newsletters, brochures, books, and other publications by computer. In Mandalay, the first DTPC was opened in 1987 with a center named “Min” on 26th street and one named “Kyemon” in Kinsanamahi Ward in CATS township. There was no progress in this service in 1988. In 1989, two more DTP centers opened, one located at the name “YMCA” and the other under the name “Cannon” in CATS township. There was again no progress in 1990. From 1991, the number of DTPCs increased continuously (Table 5). As was the case with the other centers mentioned above, the increase in this type of center was also remarkable after the late 1990s.

These DTP centers are concentrated in three localities: the south-side of the core CBD, along 30th street near a government departmental office, and in the vicinity of Mandalay University (Fig. 8). In the south-side area of the core CBD, there is a main east-west street, 35th street with a shopping area, and many private schools. This area has convenient access from other areas. On the other hand, we did find numerous DTP centers outside of the CBD. Thus, the concentration rate of DTPCs into the CBD was relatively low, about 44 percent, the lowest among the five types of centers. Therefore, DTPCs tend to be located near the local demand because the threshold of demand for location is small (Plates 7). For example, fourteen centers were found in Pyigyitagun township. As we mentioned before, there were no CASC centers in this township. Seven centers in this township were located in new commercial areas. A similar pattern was recognized in Chanmyatharsi.

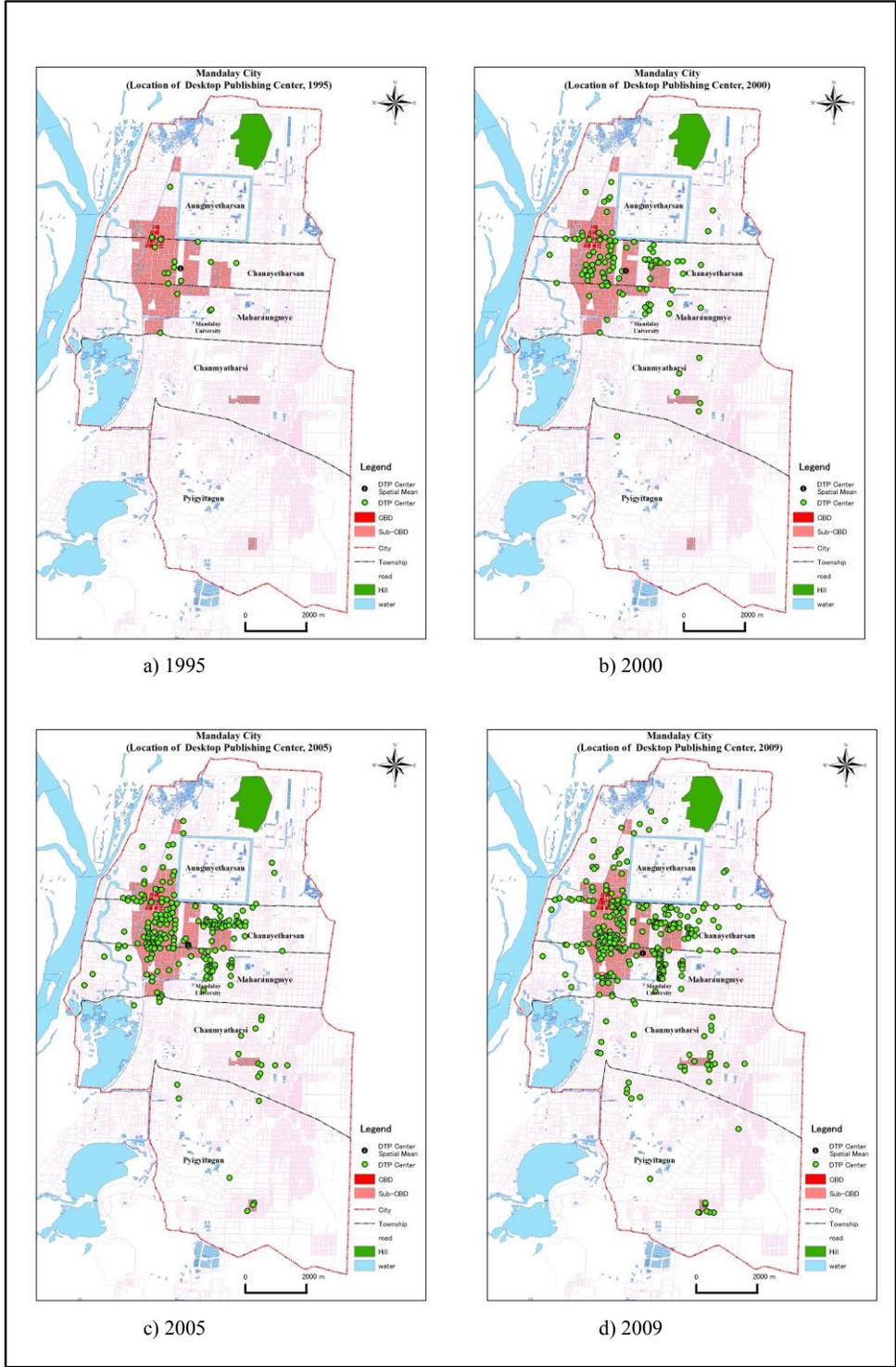
Table 5 Development of desktop publishing center within each Township

Year	Township					Total
	Aungmye tharsan	Chanayetharsan	Maharau ngmye	Chanmyatharsi	Pyigyithar	
1987		2				2
1988		2				2
1989		4				4
1990		4				4
1991		5	2			7
1992		6	2			8
1993	1	7	2			10
1994	1	8	2			11
1995	2	11	4			17
1996	2	18	7			27
1997	3	30	8			41
1998	8	44	17	4		73
1999	9	55	19	5	1	89
2000	12	60	19	5	1	97
2001	17	66	27	8	1	119
2002	24	67	28	9	4	132
2003	28	77	35	10	5	155
2004	27	88	40	10	6	171
2005	29	106	55	15	7	212
2006	29	116	59	21	9	234
2007	28	113	52	20	9	222
2008	33	107	68	28	11	247
2009	34	122	81	27	14	278
Percentage	12.2	43.9	29.1	9.7	5.1	100

Sources: Field Surveys and Mandalay Directories



Plates 7 Desktop publishing centers near government offices



Sources: Field Survey & Mandalay Directories
 Fig. 8. The spatial and temporal distribution pattern of DTPCs compared with CBD.

5. Internet Access Center (IAC)

An internet access center (IAC) is a place which offers the use of a computer with internet access, usually for a per hour or minute fee. In Mandalay, an IAC named the “Nila” center was opened in East Pyigyipyawbwe Ward, AMTS township in 2003. In 2004, the number of IACs increased to four. All of these new centers were located in CATS township. The IACs have been increasing dramatically since the commercialization of internet and mobile technologies. Therefore, these IACs show an arithmetical progression (Table 6).

Table 6 Development of Internet Access Center within each Township

Year	Township				Total
	Aungmy etharsan	Chanaye tharsan	Maharau ngmye	Chanmya tharsi Pyigyitagun	
2003	1				1
2004	1	4			5
2005	1	5			6
2006		8			8
2007		14			14
2008	3	22	5	1	31
2009	3	32	7	3	45
Percentage	6.7	71.1	15.6	6.7	100

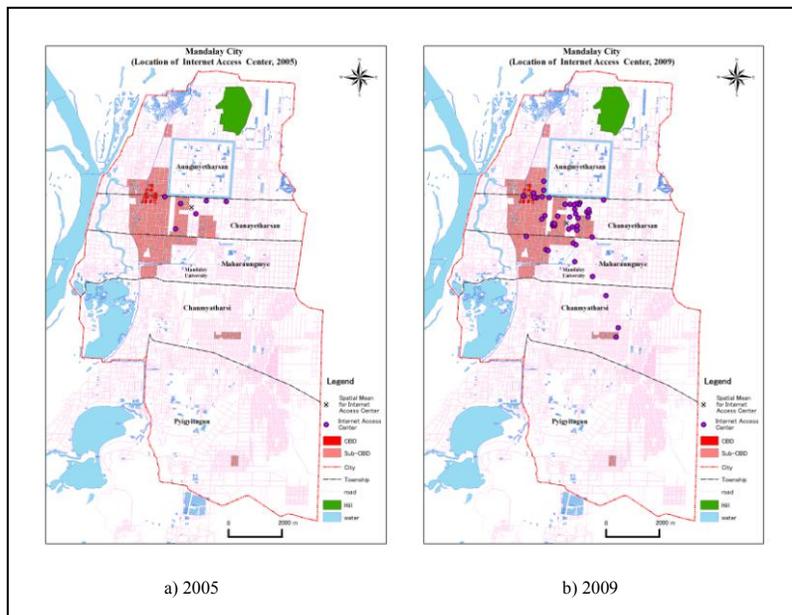
Sources: Field Survey & Mandalay Directories

In Mandalay, there were 45 IACs in 2009 (Table 6): 32 IACs in CATS township, 7 IACs in MHAM township, 3 IACs in AMTS township, and 3 IACs in CMTS township. There were no IACs in PGTG township. Out of the 45 IACs, 55.6% were located in the CBD. Many of the rest were found in the area surrounding the Palace in the north, Mandalay station in the west, 35th street in the south, and government offices in the west (Fig. 9). In this area, there is a high grade residential district, and some IACs were located there (Plates 8).



Plates 8 Internet access centers attached with residential buildings

There were few IACs in the south of the core CBD in comparison to CASCs, CRSCs and DTPCs. The area situated in the south of the core CBD is convenient to access from other areas. It is thus thought that IACs were built in this area because of access to customers concentrated in the commercial and administrative area.



Sources: Field Survey & Mandalay Directories

Fig. 9. The spatial and temporal distribution pattern of IACs compared with CBD.

6. Software Development Centers (SDC)

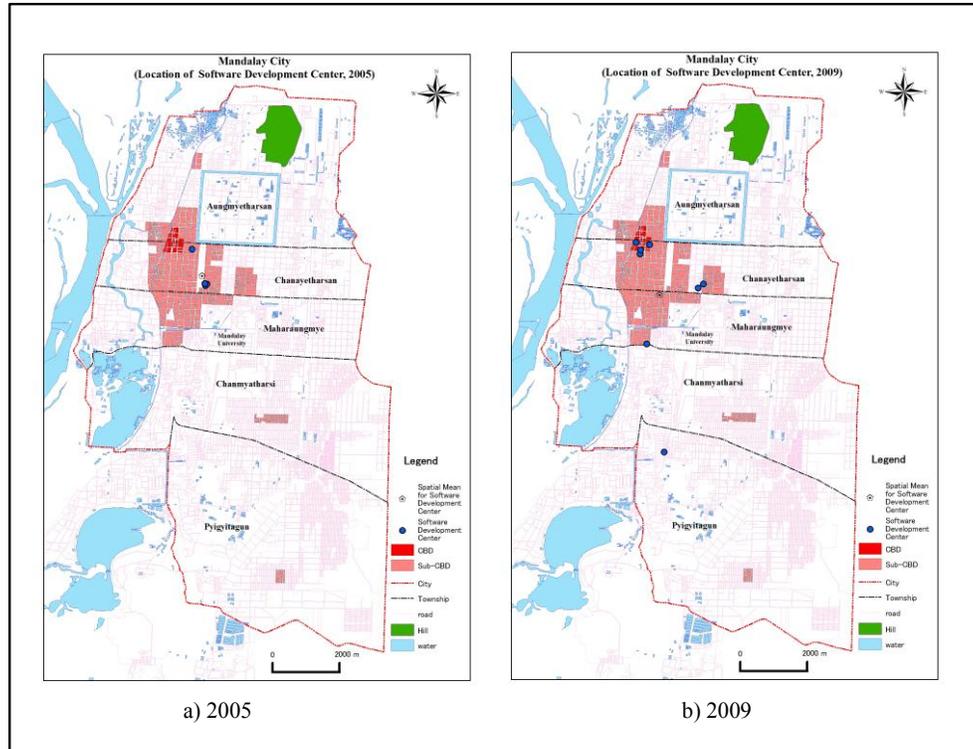
In Mandalay, four software development centers (SDCs) named the “Hi-Tech Group, Solution, Star, and Integra System Company Limited opened in 2005. Three of these companies were located in the same building, Yadanabon Shopping mall (fired on it in 2008, rebuilt it as the name of Diamond Plaza) near the railway station. The MICT (Myanmar Information and Communication Technology) park of Mandalay, a public organization that provided opportunities for various private IT companies to use cutting edge technological products, was also located in this building. The above three companies were located in MICT park. In 2006, there were 4 SDCs progress in number. These centers were located in CATS township. There were 9 SDCs in 2007, and 13 in 2008 (Table 7). In 2009, 5 SDCs closed because a fire at Yadanabon Shopping mall in 2008 destroyed them.

Table 7 Development of Software Development Center within each Township

Year	Township				Total
	Aungmye tharsan	Chanayetha rsan	Maharaung mye	Chanmy atharsi Pyigyitagun	
2005		4			4
2006		8			8
2007		8		1	9
2008		10	1	2	13
2009		6	1	1	8
Percentage		75	12.5	12.5	100

Sources: Field Survey & Mandalay Directories

In Mandalay City, there were 8 SDCs in 2009 (Table 7): 6 in CATS township, 1 in MHAM township, and 1 in PGTG township, respectively. However, there were no SDCs in AMTS and CMTS townships. Out of the 8 SDCs, 75% are in the CBD. The spatial temporal distribution of SDCs is shown in Fig. 10. SDCs do not always need to be located in the CBD, excluding subsidiary companies of main customers located in the CBD. Therefore, in the future, it is thought that the SDCs will be dispersed.



Sources: Field Survey & Mandalay Directories

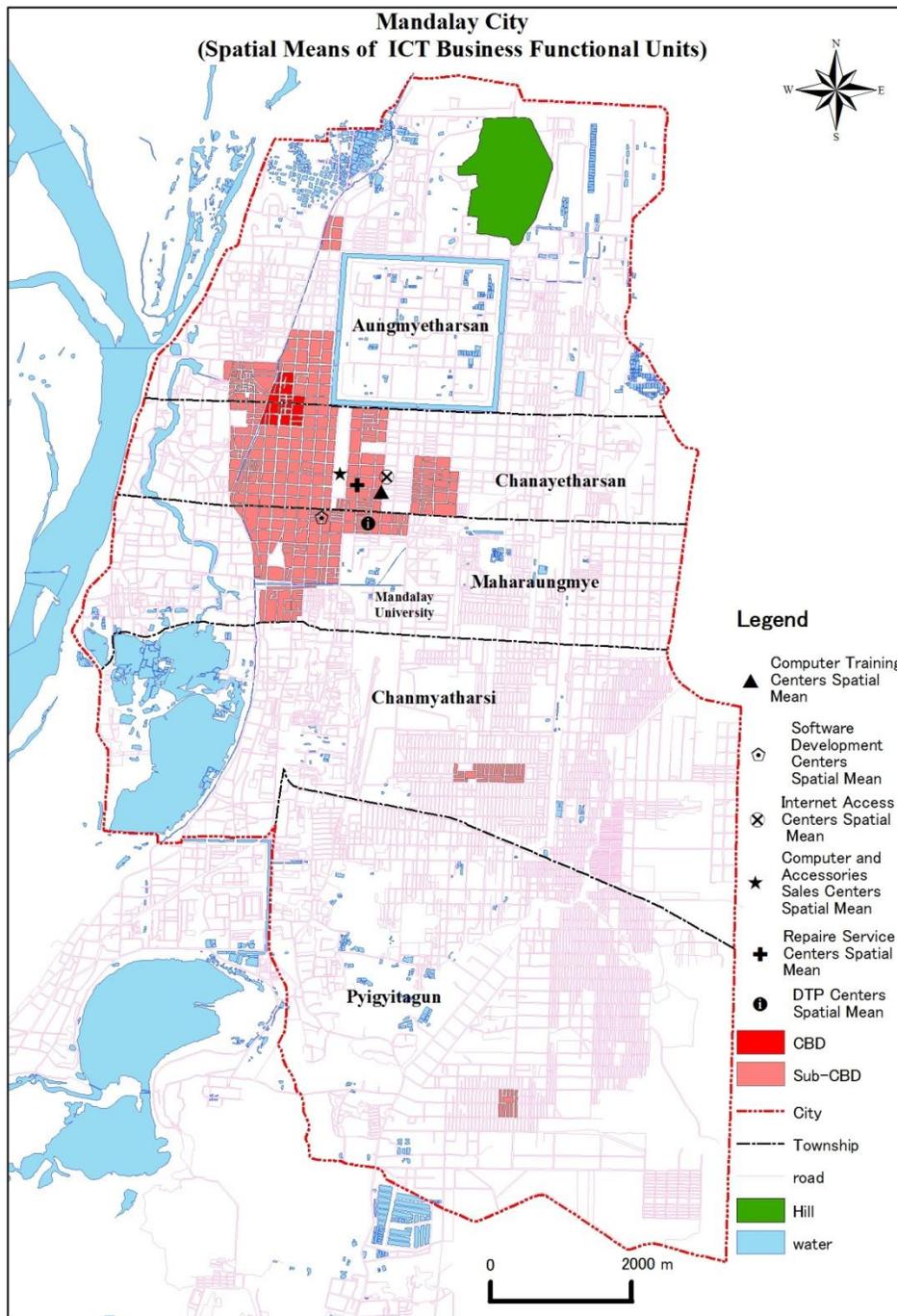
Fig. 10 The spatial temporal distribution pattern of SDCs

V. Tendency of spatial dispersion of the ICT services units

1. Spatial center of distribution of functional units

The spatial center (SC) provides the average location of a set of point locations. Whatever the points in a spatial database represent, each point may be defined operationally by a pair of coordinates (x, y) , for its location in a two-dimensional space. With the use of a coordinate system, the SMC can be obtained by computing the mean of the x coordinates (eastings) and the mean of the y coordinates (northings).

We did not consider any particular factor as a weight to be included in computing the spatial mean center since we would like to explore only the location of spatial point distribution. This is based on the assumption that the importance of individual points is equal because we are only interested in how the functional units are located. Another assumption is that the sizes of the units are negligibly small relative to the size of the city. Fig. 11 shows the spatial mean centers of six ICT service units in 2009. It can be observed that they were fairly close to each other in the CBD. In addition, they were located not in the core area of the CBD, but in the southwestern part. This is thought to correspond to the expansion of Mandalay City to the south.



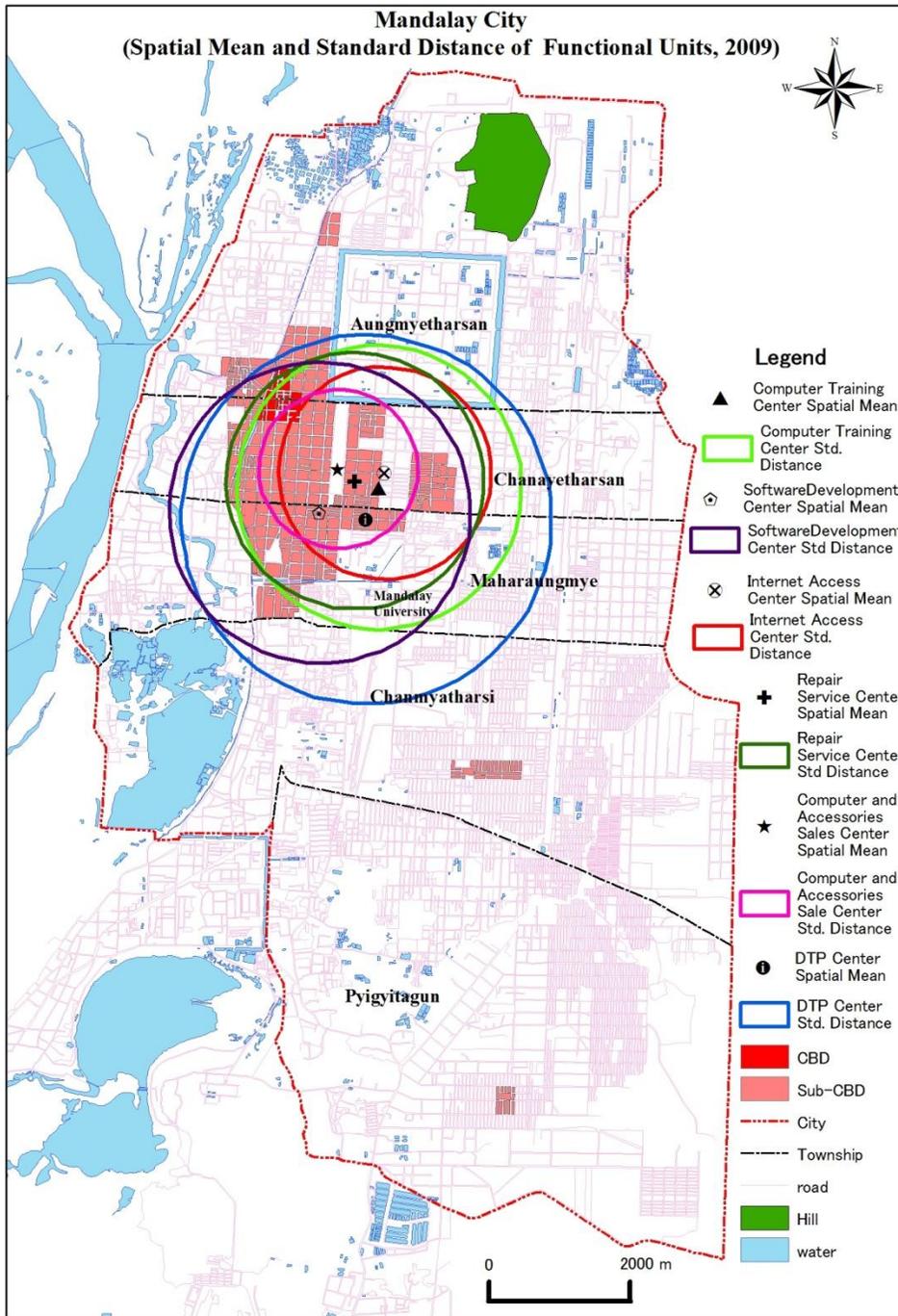
Sources: Field Survey & Mandalay Directories

Fig. 11 Spatial mean center of all ICT functional units

2. Standard distance

Standard distance (SD) is the spatial dispersion measure of standard deviation in a traditional statistics approach. We used the SD measure to demonstrate how distributions of ICT service units deviate from their SCs. SD is expressed in distance units, which are dependent on the projection system employed (please refer to Lee and Wong, 2000, pp.44-46). We did not use any particular attribute values as weight factors to compute the SD for the same reasons described earlier. Fig. 12 shows the spatial SD circles of all ICT functional units. This measure gives the information on the extent of spatial spread of the point distribution it is based on. It can be observed that the distribution of DTP center locations shows the highest deviation or dispersion from the spatial mean, and the distribution of CASCs centers has the lowest. However, the SD of CTCs, SDCs, IACs, and CRSCs are between these maximum and minimum values and are similar to each other.

These implies that the locations of DTP centers are highly dispersed in space, and that the locations of CASCs do not deviate much from the mean center, or tend to be closer to each other. However, CTCs, SDCs, IACs, and CRSCs are not as dispersed as DTPCs and not as closed as CASCs.

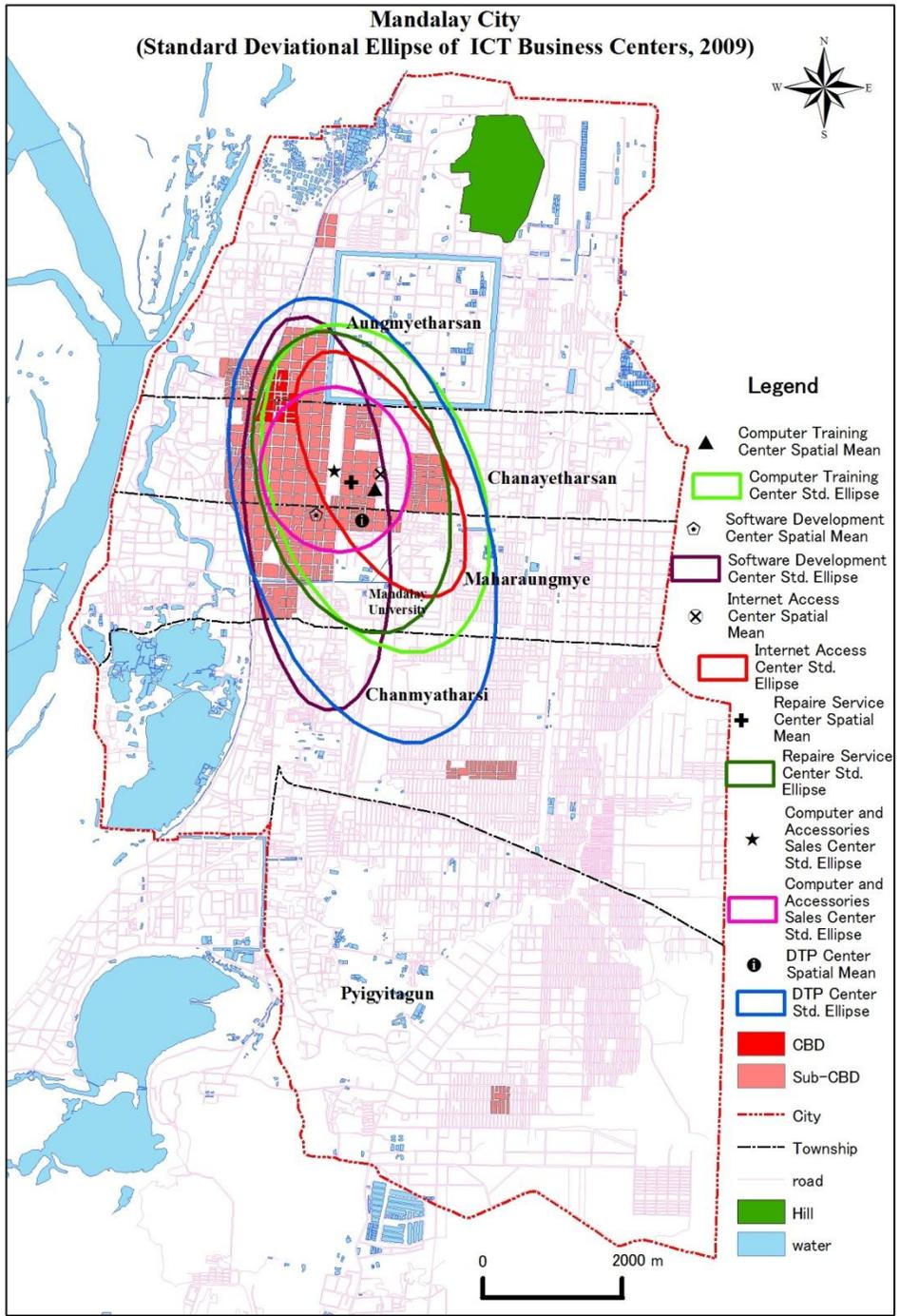


Sources: Field Survey & Mandalay Directories
 Fig. 12 Spatial dispersion of ICT service functional units

3. Standard deviational ellipse

The SD circle is an effective tool to represent the spatial dispersion of a set of point distributions in space. However, the set of point's locations may come from a particular geographic phenomenon that has a directional bias. Another measure that we employed to capture the directional bias in point distribution is the standard deviational ellipse (SDE). The SDE circle has three components: the angle of rotation, the deviation along the major axis (the longer one), and the deviation along the minor axis (the shorter one) (please refer to Lee and Wong, 2000, pp.47-57).

This analysis was carried out to explore if there were any directional biases among the ICT service units. If a set of points processes directional stretch in distribution, then there will be a direction with maximum spread of the points. This is the longer axis of the ellipse. Another axis perpendicular to the longer axis (i.e., major direction) is the direction with the minimum spread of the points. Thus, the SDE of these units can provide information on the directional bias of their location or expansions which could clearly indicate the direction of urban growth. The ellipses of the ICT service units were laid over each other to show their spatial correspondence and their directional bias (Fig. 13). It was found that the locations of the CASCs are oriented fairly equally in east-west and north-south directions. Therefore, the major axis of the SDE of CASCs is not significantly different from the minor axis, and hence it can be concluded that CASCs are more evenly distributed than other functional units. The locations of DTPCs, SDCs, CTCs, IACs, and CRSCs are oriented in the northwest and southeast directions ranging from 5 degrees to 25 degrees rotated counterclockwise from the north. In other words, the major axes of all the above functional units are oriented in the northwest to southeast directions and are almost parallel to each other. This implies that the direction of urban growth in Mandalay is either northwest to southeast. However, the orientation of all functional units only slightly deviates from a north-south direction. This shows that the urban growth is in the northwest to southeast direction. However, this does not tell us exactly which degree or how strongly the urban development is oriented. The directional bias of the selected functional units effectively represents the growth of the city. In other words, the orientation of the longer axis of all functional units expresses the direction of urban growth as we observed through the literature, field observation, images, and existing land-use land cover maps.



Sources: Field Survey & Mandalay Directories
 Fig. 13 Standard deviational ellipse of the ICT service functional unit

VI. Conclusion

We confirmed the surprising increase in ICT service industry businesses in Mandalay after the late 1980s, although this type of industry was a new industry that appeared for the first time only in 1987. The increase after the late 1990s was particularly remarkable, and corresponded to the economic growth of Myanmar. Thus, the rapid enlargement of this industry could be considered a tendency reflecting the influences of the economic liberalization policies.

ICT service centers were characterized by their concentration into the central commercial area with some differences among types. However, there were few centers in the core CBD. The geometric centers of distribution of ICT service establishments were located not at the core CBD, but south of the railway station. In particular, a lot of these businesses located south of 35th street and east sides of the station were in the frontier of extension of the commercial area. This finding suggests that the locations of ICT service centers correspond to the expansion of the central commercial area. In other words, the service centers played a role in expanding the CBD. Therefore, the central commercial area of Mandalay expanded in correspondence to the economic growth of the national state.

On the other hand, with regard to the locations of ICT service centers in the suburbs, there was a very small number of centers in the suburbs, except for DTP centers. Therefore, compared to the expansion of the central commercial area, the development of a sub central commercial area in the suburb is delayed. Since motorization is not very developed in Mandalay, the suburbs are not easy to access from other areas. As for public transportation facility, it is organized mainly that it is the center of a city. Transportation is much more convenient in the CBD than in the suburbs. This factor seems to be the main reason delaying the development of sub central commercial areas.

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