

A Research on Some Extremal Problems in Dominating Colour and Transversals of Graphs

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Abstract – The subject of this paper is an unwinding of legitimate graph colorings - bounded monochromatic component colorings (BMC colorings). A vertex-coloring of a graph is known as a BMC coloring if each color-class actuates monochromatic components containing at most a specific bounded number of vertices. A legitimate coloring for example is a BMC coloring in which each color-class instigates monochromatic components of request one. We examine three unique parts of BMC colorings.

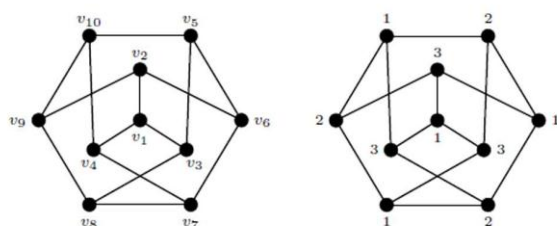
We research extremal graph theoretic problems of BMC colorings. For specific groups of graphs we decide bounds for the littlest monochromatic component, request C , the basic component request, to such an extent that each graph contained in this family obliges for a BMC coloring as for C . We decide bounds for the basic component request C for graphs with a bounded maximum degree: Every graph of maximum degree at most three concedes a BMC 2-coloring with one color-class prompting monochromatic components of request one and the other color-class instigating monochromatic components of request at most 22; and each graph of maximum degree at most five concedes a BMC 2-coloring inciting monochromatic components of request at most 1908 in every one of the two color-classes.

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INTRODUCTION

Graph Colorings : A graph G is a set $V(G)$ of vertices and a set $E(G)$ of edges, each connecting a couple of vertices, its endpoints. We state that the two endpoints of an edge curve contiguous. An illustration that demonstrates the notable Petersen Graph can be found in Figure 1(a).

essentially a partition of $V(G)$ into k independent sets (look at Figure 1(b)).



(a) Petersen Graph

(b) proper 3-coloring

Figure 1: The Petersen Graph and a legitimate 3-coloring of its vertices. An appropriate k -coloring of the vertices of a graph G is a task, of k colors (regularly the whole numbers $1, \dots, k$) so no two nearby, vertices get. a similar color, sec for example Figure 1(b) for a legitimate 3-coloring of the Petersen Graph. The set of vertices accepting color j is a color-class and instigates a graph without any edges, i.e., it is an independent set of G . Along these lines, an appropriate k -coloring of the vertices of G is

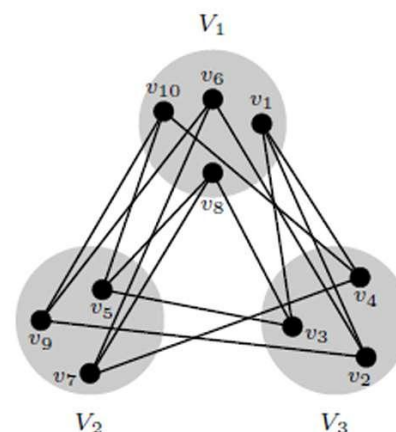


Figure 2: A partition of the Petersen Graph into three independent sets.

The chromatic number $\chi(G)$ of a graph G is the base k for which there is a χ -coloring of G . One direct purpose behind a graph to have substantial chromatic number is the control of a vast faction (i.e., an expansive complete subgraph). Clearly whether a graph G contains a faction of request k , at that point $\chi(G) \geq k$. Essentially for each subgraph $H \subseteq G$ it holds that $\chi(H) \leq \chi(G)$. Since

the Petersen Graph contains odd cycles, and an odd cycle requires no less than, three colors in any appropriate coloring, the chromatic number of the Petersen Graph is at least three. The accompanying recommendation expresses a connection between the maximum degree $\Delta(G)$ of a graph G and its chromatic number.

Bounded Component Transversals: Let us review that a transversal of a multipartite graph is a subset, of its vertices containing precisely one vertex from each partite set. The transversal graph is the graph induced by the vertices of the transversal. For an integer $f \geq 1$ we call a transversal an f -be transversal if the largest, component of the transversal graph contains at most f vertices.

The main goal of this part of the paper is to guarantee the existence of bounded component transversals for multipartite graphs that have large partite sets, with respect to their maximum degree. Moreover we want to elaborate on algorithms that even find such bounded component transversals. It seems natural that for some fixed maximum degree, the more vertices a multipartite graph contains in each of its partite sets, the more freedom is given to choose a transversal, possibly inducing only small components in the transversal graph. We have seen in Proposition 0.2 that the (list-)chromatic number of a graph can easily be upper bounded by its maximum degree, independent of the number of vertices contained in the graph. Let us for a moment focus on independent transversals, i.e., transversals inducing an independent, set.

Let G be a multipartite graph with maximum degree Δ for which the number of vertices in each of its partite sets is lower-bounded by some value $p(\Delta)$ depending only on Δ . In contrast to the greedy algorithm for proper (list-)colorings, one can observe that a greedy algorithm for choosing an independent, transversal of G - choose a vertex t_i from K that is not adjacent to any of the earlier chosen vertices t_j in G , $j < i$ is likely to fail. This algorithm can get stuck in a partial transversal t_1, \dots such that every vertex of V_{k+i} is adjacent to a vertex of $\{t_1, \dots, t_k\}$, with $k < m$.

Bounded component, transversals have proved to be very applicable in many areas of graph theory. In this paper we show an application of bounded component, transversals in order to get one tiny step closer to a proof of the Linear Arboricity Conjecture.

Bounded Monochromatic Component Colorings
Sometimes the number of colors available to color a graph is less than its chromatic number. Therefore one is forced to relax the properness condition and to find a good approximation of its properness. Another good reason to introduce relaxations of proper colorings is that in some theoretical or practical situations a small deviation from proper is still acceptable, while the problem could become

tractable, or in certain problems the use of the full strength of proper coloring is an "overkill". Often a weaker concept, suffices and provides better overall results.

DOMINATING COLOUR TRANSVERSAL

Definition 1. Give Π a chance to be a x -partition of a graph G . A set $D \subseteq V$ is said to be a transversal of Π if D crosses each color class of Π .

Definition 2. A dominating set $D \subseteq V$ is called a dominating color transversal set (sexually transmitted disease set) of a graph G if D is a transversal of no less than one x -partition of G . We consider this set a sexually transmitted disease set since it is a dominating color transversal of no less than one (single) x -partition. A sexually transmitted disease set is insignificant if none of its appropriate subsets is a sexually transmitted disease set.

Definition 3. Let $\mathcal{C} = \{D \subseteq V \mid D \text{ is an std-set of } G\}$. \mathcal{C} is non-empty as $V \in \mathcal{C}$. Let $D' \in \mathcal{C}$ whose cardinality is least. D' is known as a γ_{st} -set and its cardinality is known as the dominating color transversal number meant by γ_{st} .

Result :

(a) For any graph G .

$$1) \quad 1 \leq \gamma \leq \gamma_{st}.$$

$$2) \quad \omega \leq \chi \leq \gamma_{st}.$$

(b) For any bipartite graph G , γ_{st} is either γ or $\gamma + 1$ since by including if essential a solitary vertex to a γ -set, we get a γ_{st} -set for G .

Theorem 1 : A sexually transmitted disease set D is insignificant if and if for each $u \in D$ any of the accompanying holds:

(i) u is a disengage of D

(ii) there exists a vertex $v \in V - D$ such that $N(v) \cap D = \{u\}$

(iii) for each x -partition, $\Pi = \{V_1, V_2, \dots, V_x\}$, there exists one V_i with the end goal that $V_i \cap D = \{u\}$ or \emptyset .

Proof. Give D a chance to be a sexually transmitted disease set.

In the event that D is negligible, at that point $D - \{u\}$ isn't a sexually transmitted disease set for each

$u \in D$. This infers either $D - \{u\}$ is certainly not a dominating set or not a transversal of each x -partition of G .

Case 1: Suppose $D - \{u\}$ is certainly not a dominating set. At that point there exists a vertex $v \in (V - D) \cup \{u\}$ that isn't adjoining any vertex of $D - \{u\}$. In the event that $u = v$, at that point u is a confine of D . In the event that $u \neq v$, at that point is neighboring u yet not to some other vertex of D . Henceforth $N(v) \cap D = \{u\}$.

Case 2: Suppose $D - \{u\}$ is definitely not a transversal for each x -partition $\{V_1, V_2, \dots, V_k\}$. This suggests $D - \{u\} \cap V_i = \emptyset$ for some i . That is $V_i \cap D = \{u\}$ or \emptyset for some i . Thus (iii) is fulfilled.

Conversely assume any one of the three conditions. We prove that D is a minimal std-set. Suppose not. Then D is an std-set but not minimal. This implies that D and $D - \{u\}$ are std-sets for some $u \in D$.

Let $\{V_1, V_2, \dots, V_k\}$ be a x -partition of V for which $D - \{u\}$ and D are transversals. Then $D - \{u\} \cap V_i \neq \emptyset$ and $D \cap V_i \neq \emptyset$ for every i . This implies that $D \cap V_i \neq \{u\}$ or \emptyset contradicting condition (iii). \square

Theorem 2: For any graph G , $\gamma \leq \gamma_g \leq \gamma_{st}$.

Proof. Let D be any std-set of G . So there exists a x -partition $\Pi = \{V_1, V_2, \dots, V_k\}$ such that $D \cap V_i \neq \emptyset$ for every i . Each V_i is an independent set and so is a clique in \overline{G} . Since $D \cap V_i \neq \emptyset$ for every i , D is a dominating set for \overline{G} . Hence D is a global dominating set and $\gamma_g \leq \gamma_{st}$.

Result : If G has k -components say G_1, G_2, \dots, G_k such that $\chi(G_1) \geq \chi(G_i)$ for $i = 2, 3, \dots, k$, then $\gamma_{st}(G) \leq \gamma_{st}(G_1) + \sum_{i=2}^k \gamma(G_i)$.

Proof. It is given that $G = \bigcup_{i=1}^k G_i$.

As $\chi(G_1) \geq \chi(G_i)$, for every i , any γ_{st} -set of $G \setminus G_i$ is a transversal of every x -partition of G . Hence the union of a γ_{st} -set of $G \setminus G_i$ and γ -sets of G_i , $i=2, 3, \dots, k$ is an std-set of G . So $\gamma_{st}(G) \leq \gamma_{st}(G_1) + \sum_{i=2}^k \gamma(G_i)$.

Result: If G has k -components G_1, G_2, \dots, G_k such that $\chi(G_i) \leq \chi(G_1) \leq k$ for $i = 2, 3, \dots, k$, then $\gamma_{st}(G) = \sum_{i=1}^k \gamma(G_i)$.

Proof. The union of γ -sets of G_i for $i = 1, 2, \dots, k$, is a γ -set of G . Since $k \leq \chi(G) = \chi(G_1) \leq \chi(G_i)$, it is always possible to obtain a x -partition for G such that any union of γ -sets of $i = 1, 2, \dots, k$ is a transversal of this x -partition. Hence $\gamma_{st} = \sum_{i=1}^k \gamma(G_i)$.

Bounded Component Transversals

Let G be a multipartite graph with $V(G) = V_1 \cup \dots \cup V_m$. A transversal T of G is a subset of the vertices in G containing precisely one vertex from each partite set V^* . A f -bc transversal of a graph with a vertex partition is a transversal T in which each associated component of the subgraph instigated by T (the transversal graph) has at most f vertices. Let $\Delta_f(m, n)$ denote the smallest integer Δ such that there exists an m -partite graph G with maximum degree A and parts of size n and with no f -bc transversal. We define $\Delta_f(n) = \min_{m \in \mathbb{N}} \Delta_f(m, n)$ in case we do not want to restrict the number of parts in the graphs under consideration and let Δ_f denote $\lim_{n \rightarrow \infty} \Delta_f(n)/n$. It is not hard to check that this limit always exists.

Independent Transversals : Historically the investigation of $\Delta_f(m, n)$ started with 1-bc transversals, subsequently called independent transversals. Independent transversals and in particular the determination of the number $\Delta_1(m, n)$, for $m \geq 2$ and $n \geq 1$ received a lot of attention. In a series of works $\Delta_1(m, n)$ has been completely determined.

Theorem 1.3. For integers $m \geq 2$ and $n \geq 1$ the following holds,

$$\Delta_1(m, n) = \begin{cases} \lceil \frac{(m-1)n}{2(m-2)} \rceil, & \text{if } m \text{ is odd, and} \\ \lceil \frac{mn}{2(m-1)} \rceil, & \text{if } m \text{ is even.} \end{cases}$$

The upper bound for all m and n has been proved by Szabo and Tardos for even m in and in is has been shown that this construction is also optimal for odd m (adding one more partite set). We give here a simplified construction showing $n/2 < \Delta_1(m, n) \leq \lceil n/2 \rceil + 1$ for $m - 2 \geq N$ only. This yields a tight bound if n is even. Let G be the graph (a vertex represents a whole class of vertices). That is, G is an r -partite graph with partite sets of size n , $m > n$ and each partite set $V_i, i \in [m - 2]$ is partitioned into two almost equally sized classes $V_{i,1}$ and $V_{i,2}$ (i.e., $|V_{i,1}| = \lfloor n/2 \rfloor$ and $|V_{i,2}| = \lceil n/2 \rceil$). Let every vertex in part $V_{i,2}$ be adjacent to every vertex in $V_{i+1,1}$, with $i \in [m - 3]$ and let every

vertex in $V_{m-2,2}$ be adjacent, to every vertex in $V_{i,1}$. We assume that, the two parts V_{m-1} and V_m each contain $n \leq m-2$ vertices $v_{m-1,1}, v_{m-1,2}, \dots, v_{m-1,n}$ and $v_{m,1}, v_{m,2}, \dots, v_{m,n}$, respectively. Further let every vertex of $V_{i,j}$ be adjacent to $v_{m+1-j,i}$, $i \in [n]$ and $j \in \{1, 2\}$

Matching Transversals : Let us finally restrict to 2-bc transversals which we subsequently want to call a matching transversals. According to Theorem every multipartite graph G with partite sets of order n and $\Delta(G) \leq \lfloor 2n/3 \rfloor$ contains a matching transversal. On the other hand according to Proposition there are multipartite graphs with partite sets of order n and $\Delta(G) = n+1$ without a matching transversal. We think that these graphs are in some sense optimal.

Theorem. Every multipartite graph G with partite sets of order at least two and with maximum degree $\Delta(G) \leq 2$ contains a matching transversal T , i.e., $\Delta_2(2) = 2$. Moreover there is a linear-time (in the order of G) algorithm that finds T . We will investigate $\Delta_f(r, n)$ for matching transversals ($f = 2$). We can construct graphs such that the following holds.

BMC Colorings

Let us recall the definition of BMC colorings. We say that a f -coloring of a graph is (C_1, C_2, \dots, C_k) -BMC if every monochromatic component induced by the vertices of the z th color-class is of order at most C_z , for $i \in [k]$. Note that a $(1, \dots, 1)$ -BMC k -coloring corresponds to a proper k -coloring. We mainly deal with the two most natural cases of BMC k -colorings. We say C -symmetric BMC k -coloring (also C -sbmc k -coloring) when $C_i = C$, for $i \in [k]$. Similarly we say C -asymmetric BMC (k, l) -coloring (also C -ABMC (k, l) -coloring) when $C_i = 1$, for $1 \leq i \leq k$ and $C_j = C$, for $k+1 \leq j \leq k+l$. For 2-colorings refer to a C -ABMC $(1, l)$ -coloring also by a C -ABMC 2-coloring.

In this part of the paper we investigate BMC colorings of graphs with bounded maximum degree. Symmetric BMC colorings were first studied by Kleinberg, Motwani, Raghavan, and Venkatasubramanian in. In this paper we focus on BMC 2-colorings. Symmetric BMC 2-colorings have been studied by Alon, Ding, Oporowski, and Vertigan and implicitly, even earlier, by Thomassen who resolved the problem for the line graph of 3-regular graphs initiated by Akiyama and Chvatal. Asymmetric BMC 2-colorings were first introduced in a joint paper with Tibor Szabo.

In this paper we investigate BMC k -colorings of bounded degree (planar) graphs, $k > 2$.

Also Haxell, Szabo, and Tardos in, Linial, Matousek, Shchect, and Tardos in, and Matousek and Prfvetiv in investigated (symmetric) BMC colorings.

Independently Andrews and Jacobson, Harary and Jones, and Cowen, Cowen, and Woodall presented and explored the idea of inappropriate colorings over different groups of graphs. A x -coloring is called f -ill-advised if none of the at most k colors instigates a monochromatic component containing vertices of degree bigger than f . Hence in an ill-advised coloring the measure of mistake is estimated regarding the maximum degree of monochromatic components instead of as far as their request. A few papers on the subject have since showed up; specifically, two papers, by Eaton and Hull and Skrcovski, have broadened crafted by Cowen et al. to a rundown coloring variation of ill-advised colorings.

Linial and Saks contemplated low distance across graph deteriorations, where the nature of the coloring is estimated by the measurement of the monochromatic components. Their objective was to color graphs with as few colors as conceivable to such an extent that each monochromatic associated component has a little measurement.

Haxell, Pikhurko, and Thomason consider the fragment ability of graphs presented by Edwards and Farr, specifically for bounded degree graphs. A graph is called (α, f) -fragmentable in the event that one can evacuate a small amount of the vertices and end up with components of request at generally f . For correlation, in a C -ABMC 2-coloring one must expel an independent set and end up with little components.

The alleged loosened up chromatic number (here and there additionally called generalized chromatic number) was presented by Weaver and West. They utilized "unwinding" in a substantially more broad sense than us, requiring that each color-class is the individual from a given group of graphs.

TRANSVERSALS IN GRAPHS: EXTREMAL PROBLEMS

Give G a chance to be a graph and given \mathcal{P} a chance to be a partition of $V(G)$ into sets V_1, \dots, V_n . A transversal (of \mathcal{P}) is a subset T of $V(G)$ for which $|T \cap V_i| = 1$ for each $i = 1, \dots, n$. The starting purpose of our discourse is the accompanying theorem of Haxell.

Theorem .1 Let G be a graph of maximum degree d and $V_1 \cup \dots \cup V_n = V(G)$ be a partition of its vertex set with $|V_i| \geq 2d$. Then there is a transversal T which is an independent set in G .

This theorem appears to have seemed first expressly in Haxell (2001), in spite of the fact that it

is additionally a consequence of a progressively broad consequence of Meshulam (2001) and verifiably, considerably prior, of Haxell (1995). The outcome has two proofs: one combinatorial and another by means of combinatorial topology; it isn't clear how intently these two contentions are connected. The announcement likewise has a few applications in various, problems of graph theory. In the present paper we set to think about the speculations of Theorem 1 out of two distinct headings.

Acyclic transversals with bounded components -

The primary speculation we consider here was presented in P. Haxell (2003) so as to enhance an aftereffect of Alon, Ding, Oporowski and Vertigan (2003). For a fixed degree d and component measure r , let us characterize $p(d, r)$ to be the littlest number to such an extent that any graph with maximum degree at most d partitioned into classes of size at any rate $p(d, r)$ has a transversal that prompts components of size at generally r . Theorem 1 would then be able to be reworded as $p(d, 1) \leq 2d$. A speculation of the combinatorial contention of [10] suggested that $p(d, r) \leq d + \lceil d/r \rceil$ for any d and r . This was known to hold with fairness just when $r = 1$ and d is an intensity of 2.

Sadly, for $r > 1$ even the asymptotical truth escapes us. The gauge isn't tight by and large: $p(2, 2) = 2$. Actually, the best lower bound known for $r > 1$ is $p(d, r) \geq d$ and even $p(d, 2) = d$ is conceivable right now. There was trust that a speculation of the "topological" contention could give more grounded upper bounds. In the present paper we give this missing proof by means of Sperner's Lemma and suitable triangulations of the simplex. Oh dear, we end up with precisely the same outcome which pursues from the combinatorial partner. For the proof we build triangulations which sum up the ones of Aharoni, Chudnovsky and Kotlov (2002) and after that complete along the lines of Aharoni and Haxell (2000) applying Sperner's Lemma for our suitably characterized colored triangulation. Truth be told, We get a marginally more grounded articulation. We demonstrate that if the class sizes are at any rate $d + \lceil d/r \rceil$, at that point a transversal could be chosen instigating associated components which are trees on at most r vertices.

One of our principle instruments for this fortifying is a triangulation from R. Aharoni, (2002). In We acquire a bound $p(d, \text{timberland}) \leq d$ on the base class measure $p(d, \text{backwoods})$ with the end goal that any graph of maximum degree at most d partitioned into classes of size $p(d, \text{timberland})$ has a transversal initiating a woods. We permit multigraphs in this definition. We demonstrate that this bound is ideal for even d . For basic graphs the practically equivalent to esteem may be to some degree lower however. Our

best development here for $H = K_3$. For an even d this development gives a maximum degree d graph G_d whose vertices are partitioned into classes of size and transversal of G_d is triangle-free. $\lceil \frac{3}{4}d \rceil - 1$

We note that our proof suggests that the r -component complex $\mathcal{K}_r(G)$ of a d -normal graph G with many (more than $(m + 1)(d - 1 + (d + 1)/r)$) vertices is m -associated. Here $\mathcal{K}_r(G)$ indicates the simplicial complex characterized on the vertex set of G , where a subset frames a simplex if every single associated component of the incited subgraph is of request at generally r .

Lamentably our proof does not choose the asymptotics of $p(d, r)$ for $r > 1$. Consequently it is normal to research "how great" such proofs could progress toward becoming with a perhaps progressively sharp decision of colored triangulations. We find that for $r = 2$, where the fact of the matter is among d and $\frac{3}{2}d$, there is an inborn point of confinement of $\frac{5}{4}d$ to where such sort of contentions could improve the upper bound. Specifically, for $d = 2$, the combinatorial proof of $p(2, 2) = 2$ can't be substituted by a topological contention.

H-free transversals -

The second bearing we mean to sum up Theorem 1 is about H -free-transversals. Given a fixed graph H , let $p(d, H)$ be the littlest whole number with the end goal that any graph of maximum degree at most d partitioned into classes of size at any rate $p(d, H)$ concedes a transversal with no subgraph isomorphic to H . Theorem 1 can be stated as $p(d, K_2) \leq 2d$. We discover the instance of $H = K_k$ especially fascinating, however now we are just ready to give a lower bound which we guess to be most ideal.

For any r -ordinary graph H on n vertices and for any d distinct by r , in Corollary 3.8 we demonstrate that $p(d, H) \geq \frac{n}{(n-1)^r} d$. The special instance of a similar development sets up $p(d, 1) = p(d, K_2) = 2d$ for each d . Prior this was known for forces of 2.

Give $\Delta(r, n)$ a chance to be the biggest whole number to such an extent that any r -partite graph $Gr(n)$ with vertex classes V_t of size n each and of maximum degree under $\Delta(r, n)$ contains an independent transversal, i.e., an independent set containing one vertex from each V^* . Characterize $\Delta_r = \lim_{n \rightarrow \infty} \Delta(r, n)/n$, where the farthest point is effectively observed to exist. Inconsequentially $\Delta(2, n) = n$, subsequently $\Delta_2 = 1$. Graver (c.f. [9]) showed $\Delta_3 = 1$. Bollobas, Erdos and Szemerédi (1975) demonstrated that $\frac{2}{r} \leq \Delta_r \leq \frac{1}{2} + \frac{1}{r-2}$, along these lines setting up

$\mu = \lim_{r \rightarrow \infty} \Delta_r \leq 1/2$. Alon (1988) appeared $\Delta_r \geq 1/(2e)$ for every r . This was improved to $\Delta_r \geq 1/2$ by Haxell (2001) thus eventually settling a guess of B. Bollob (1975) and building up $\mu = 1/2$.

Accurate estimations of Δ_r were known just when $r = 3, 5$ or an intensity of $\ast 2$. Alon (2003) saw that a theorem of Aharoni and Haxell additionally gives $\Delta_r \geq \left\lceil \frac{r}{2(r-1)} \right\rceil$. This can be combined with the developments of Jin to give $\Delta_r = \frac{r}{2r-1}$ for $r = 2^p$. For other integers r , the upper bounds of Jin were to some degree improved by Alon, yet accurate outcomes were not known.

CONCLUSION

Theory of mastery and graph coloring theory are two vital just as quickest developing regions in combinatorics. Various varieties of mastery have been presented by a few creators. In this grouping, Benedict et al. presented another variety in control, specifically, chromatic transversal mastery which includes both mastery and coloring. Additionally partitioning the vertex set V of a graph G into subsets of V having some property is one heading of research in graph theory. For example, one such partition is domatic partition which is a partition of V into dominating sets. Similarly, we here interest each set in the partition of V to have the property of chromatic transversal control rather than just mastery and consider this partition a chromatic transversal domatic partition. Further, the maximum request of such partition is known as the chromatic transversal domatic number which is indicated by $dct(G)$.

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