

Comparing matchings

Definition

The **symmetric difference** of M and M' consists of those edges that appear in exactly one of M and M' :

$$M \Delta M' = (M \setminus M') \cup (M' \setminus M).$$

Comparing matchings

Definition

The **symmetric difference** of M and M' consists of those edges that appear in exactly one of M and M' :

$$M \Delta M' = (M \setminus M') \cup (M' \setminus M).$$

Lemma

If M and M' are matchings, then every component of $M \Delta M'$ is a path or an even cycle.

Comparing matchings

Definition

The **symmetric difference** of M and M' consists of those edges that appear in exactly one of M and M' :

$$M \Delta M' = (M \setminus M') \cup (M' \setminus M).$$

Lemma

If M and M' are matchings, then every component of $M \Delta M'$ is a path or an even cycle.

Theorem (Berge '57)

A matching M in a graph G is a maximum matching if and only if G has no M -augmenting path.

Hall's matching condition

Important special case: matchings of bipartite graphs.

Hall's matching condition

Important special case: matchings of bipartite graphs.

Problem: Given a bipartite graph with partite sets X and Y , does it have a matching that saturates X ?

Hall's matching condition

Important special case: matchings of bipartite graphs.

Problem: Given a bipartite graph with partite sets X and Y , does it have a matching that saturates X ?

Observation: If M saturates X , then for any $S \subseteq X$ we must have $|N(S)| \geq |S|$.

Hall's matching condition

Important special case: matchings of bipartite graphs.

Problem: Given a bipartite graph with partite sets X and Y , does it have a matching that saturates X ?

Observation: If M saturates X , then for any $S \subseteq X$ we must have $|N(S)| \geq |S|$.

Theorem (Hall's Theorem, 1935)

An X, Y -bipartite graph G has a matching that saturates X if and only if $|N(S)| \geq |S|$ for all $S \subseteq X$.

Hall's matching condition

Important special case: matchings of bipartite graphs.

Problem: Given a bipartite graph with partite sets X and Y , does it have a matching that saturates X ?

Observation: If M saturates X , then for any $S \subseteq X$ we must have $|N(S)| \geq |S|$.

Theorem (Hall's Theorem, 1935)

An X, Y -bipartite graph G has a matching that saturates X if and only if $|N(S)| \geq |S|$ for all $S \subseteq X$.

When $|X| = |Y|$, Hall's Theorem is sometimes referred to as the **Marriage Theorem**.

Hall's matching condition

Important special case: matchings of bipartite graphs.

Problem: Given a bipartite graph with partite sets X and Y , does it have a matching that saturates X ?

Observation: If M saturates X , then for any $S \subseteq X$ we must have $|N(S)| \geq |S|$.

Theorem (Hall's Theorem, 1935)

An X, Y -bipartite graph G has a matching that saturates X if and only if $|N(S)| \geq |S|$ for all $S \subseteq X$.

When $|X| = |Y|$, Hall's Theorem is sometimes referred to as the **Marriage Theorem**.

Corollary

For $k > 0$, every k -regular bipartite graph has a perfect matching.