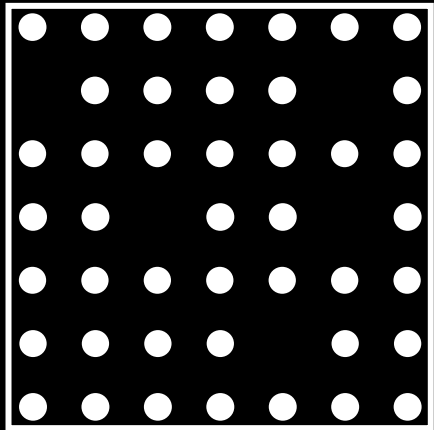


Mathematics of Digital Hyperspace

Jeremy Kepner, Timothy Davis, Vijay Gadepally,
Hayden Jananthan, Lauren Milechin

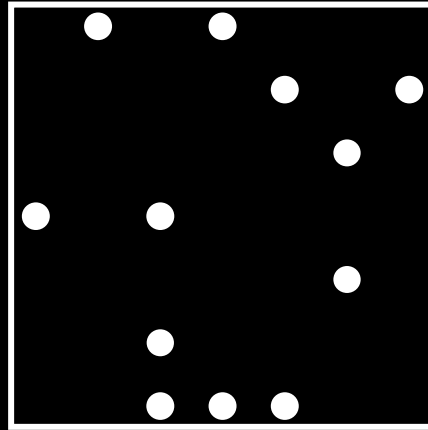
NxN Matrices

Dense



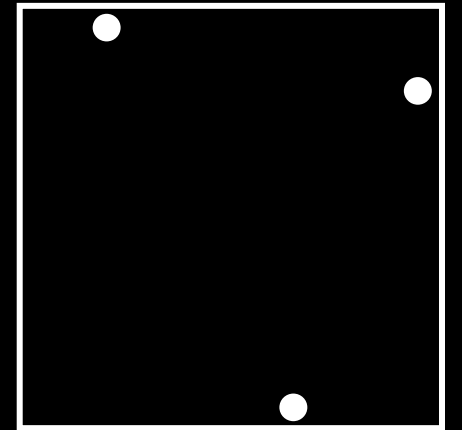
nonzeros $\sim N^2$

Sparse



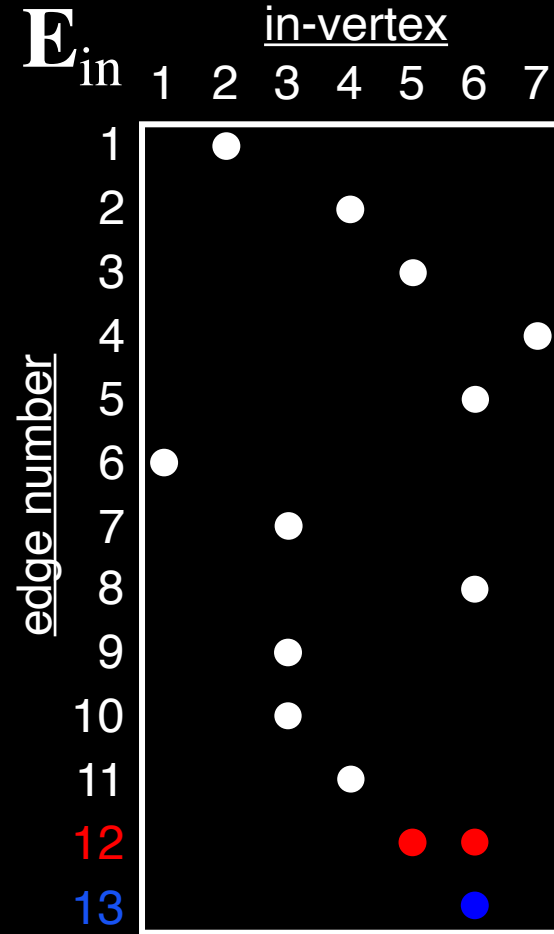
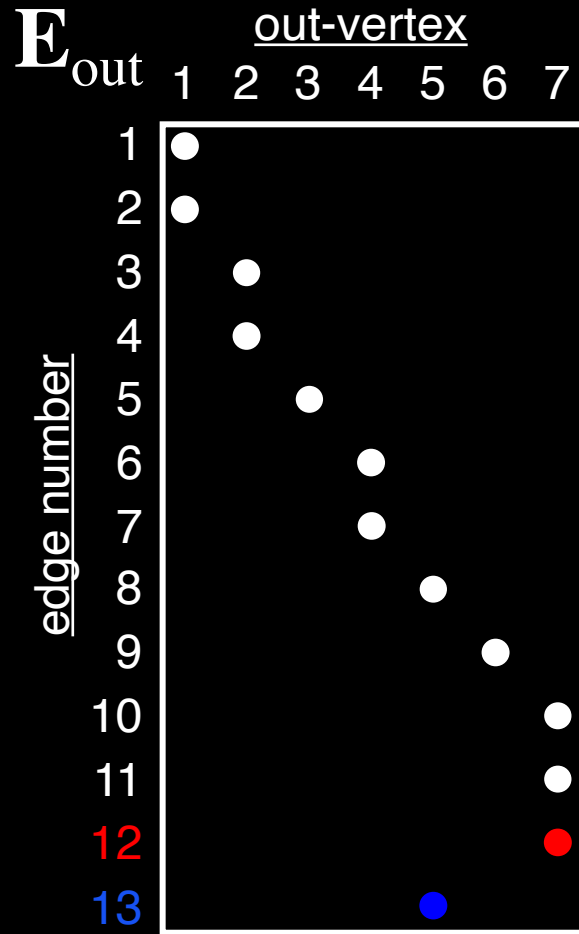
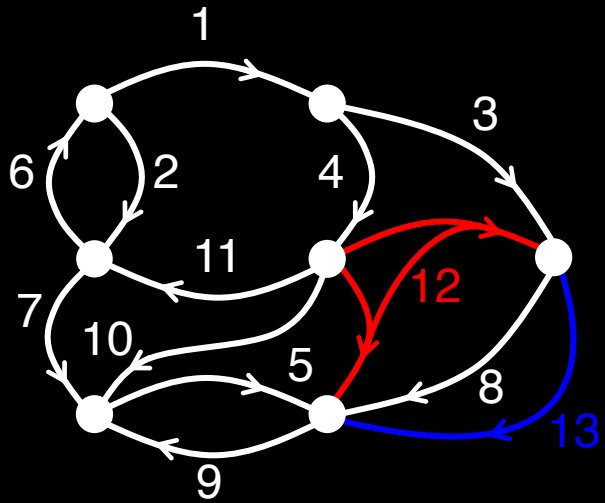
nonzeros $\sim N$

Hypersparse

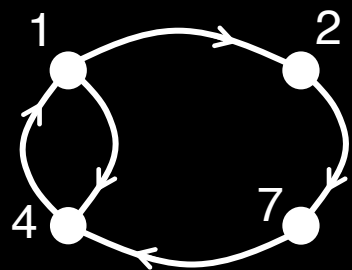


nonzeros $\ll N$

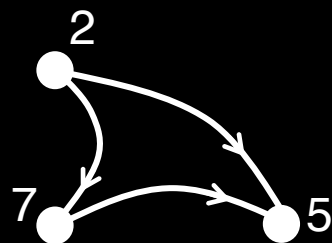
Hyper-Multi-Graphs



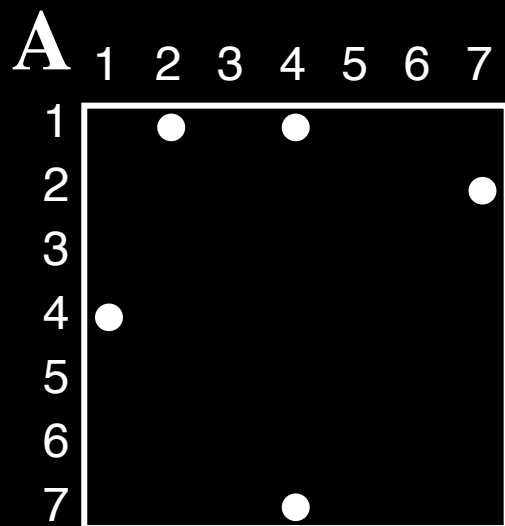
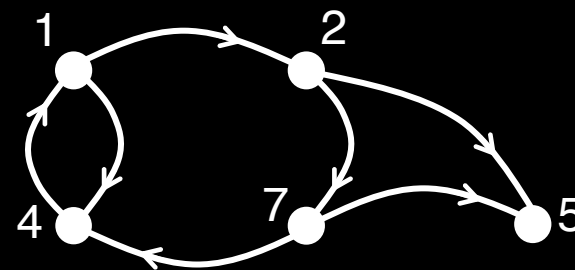
Graph Element-Wise Addition \oplus



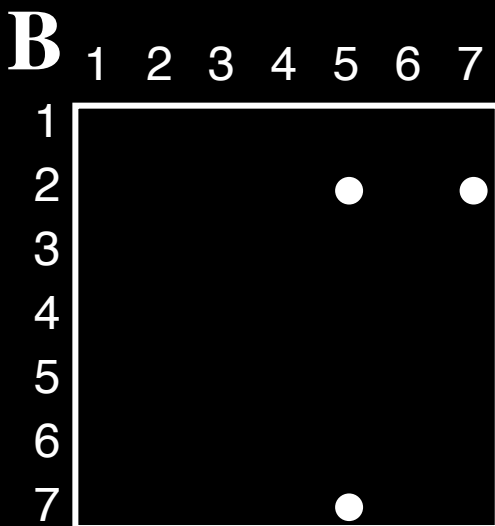
\oplus



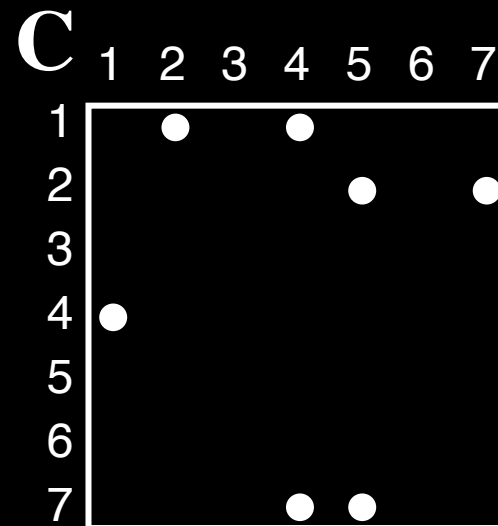
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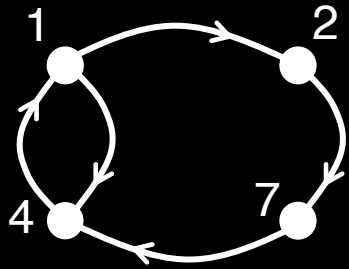
\oplus



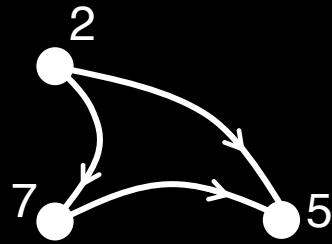
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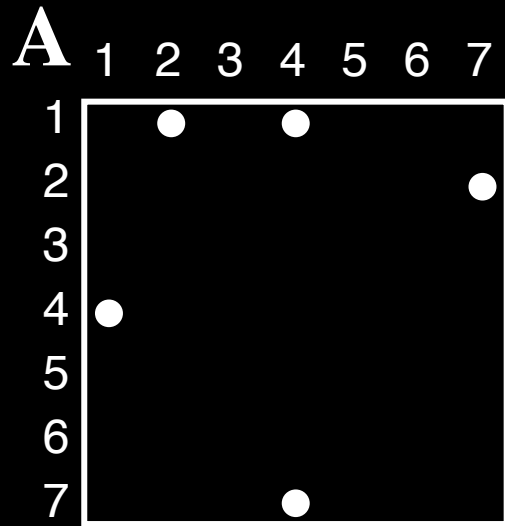
Graph Element-Wise Multiplication \otimes



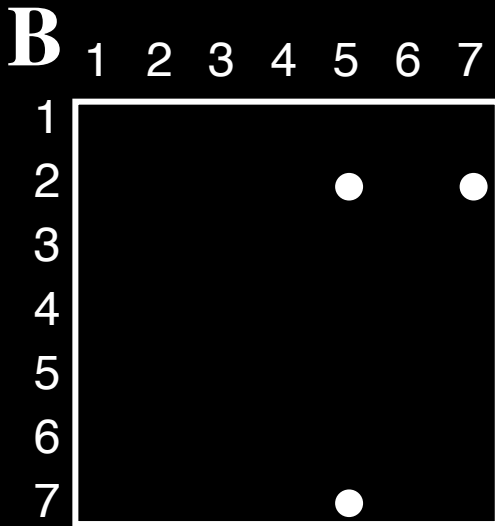
\otimes



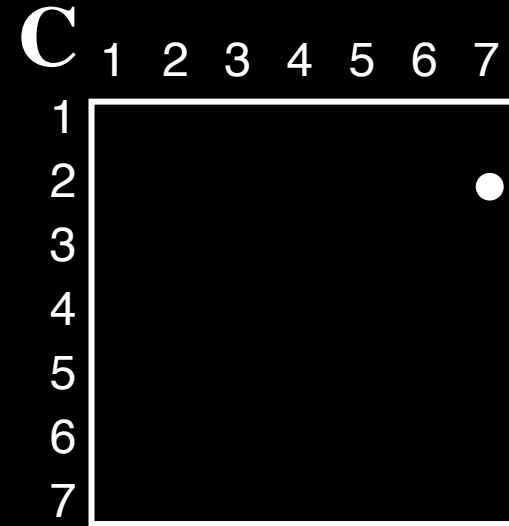
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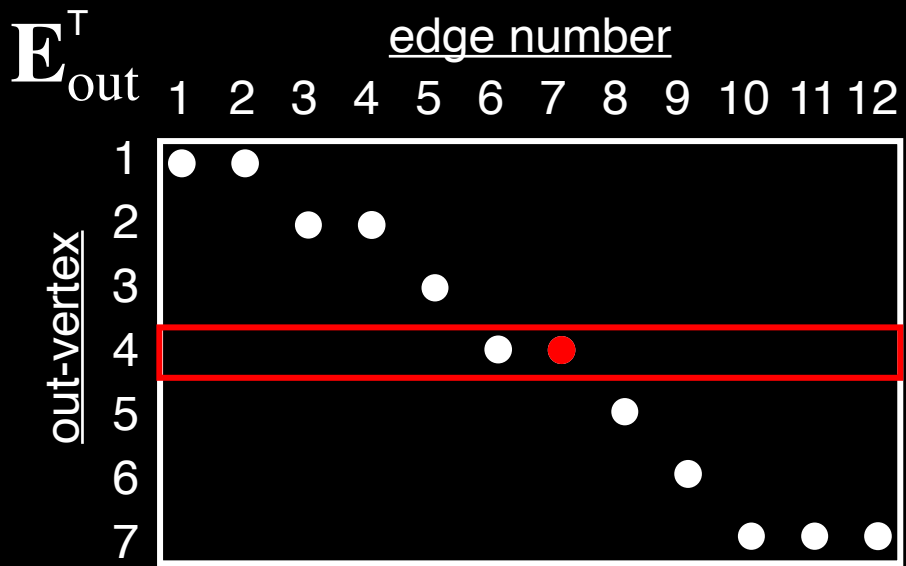
\otimes



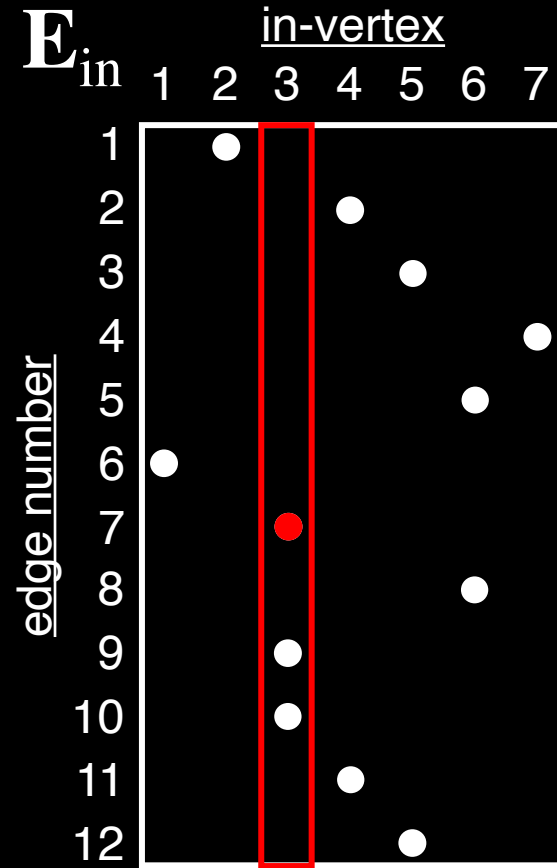
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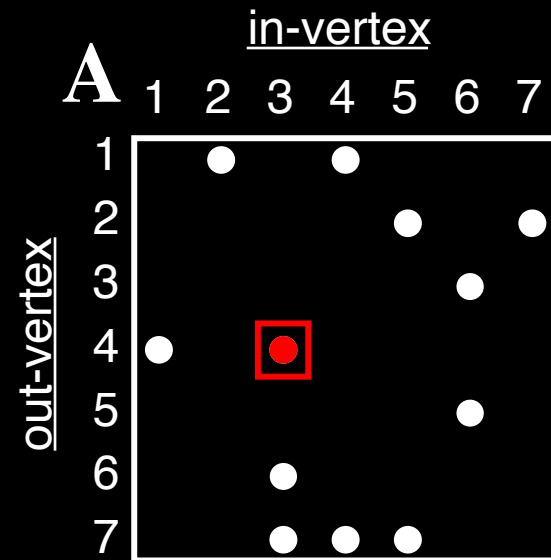
Graph Matrix Multiplication $\oplus.\otimes$



$\oplus.\otimes$



=



Semirings and the Distributive Property

$$2 \times (3 + 4) = (2 \times 3) + (2 \times 4)$$
$$2 \otimes (3 \oplus 4) = (2 \otimes 3) \oplus (2 \otimes 4)$$

$$\oplus = +$$

$$\otimes = \times$$

$$\oplus = \max$$

$$\otimes = +$$

$$\oplus = \cup$$

$$\otimes = \cap$$

Semirings and the Distributive Property

$$A \otimes (B \oplus C) = (A \otimes B) \oplus (A \otimes C)$$

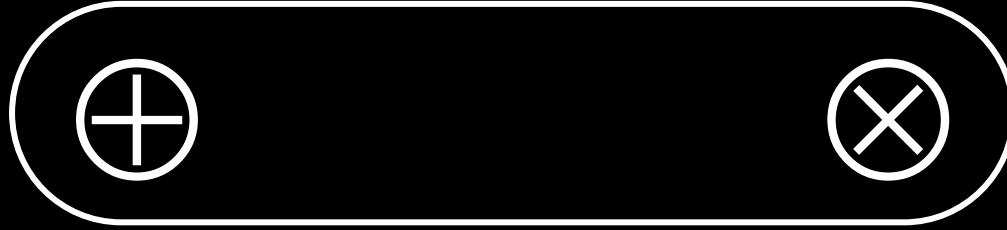
A B C spreadsheets

A B C database tables

A B C matrices

A B C graphs/networks

Semiring Pair



Semilink

