A Collection of PGF/TikZ Examples for Deep Learning

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January 24, 2019 (v0.1.0)

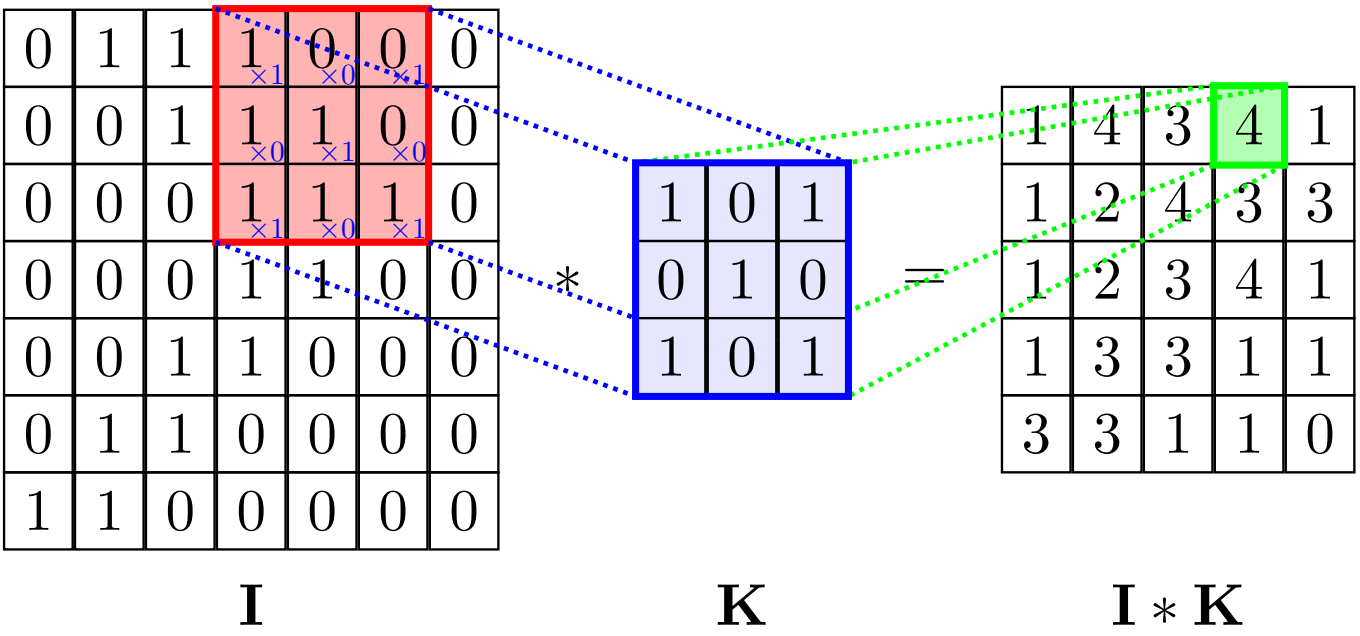
Abstract

This document is a collection of common examples for scientific papers particularly for Deep Learning topics by using PGF/TikZ package. Reference: https://github.com/PetarV-/TikZ.

Contents

1 Deep Learning

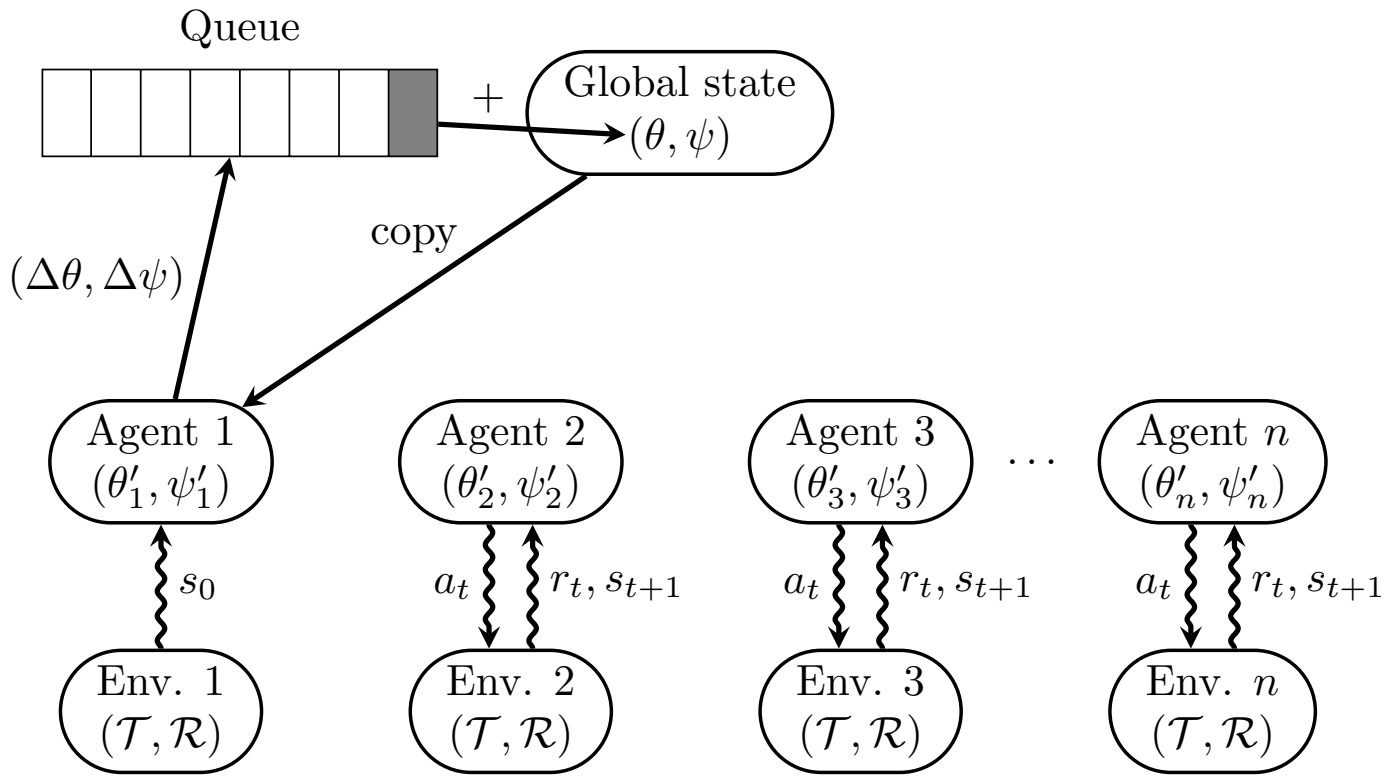
1.1 2D Convolution Operation




```
\begin{tikzpicture}

    \matrix (mtr) [matrix of nodes,row sep=-\pgflinewidth, nodes={draw}]
    {
        0 & 1 & 1 & |[fill=red!30]| 1 & |[fill=red!30]| 0 & |[fill=red!30]| 0 & 0\\
        0 & 0 & 1 & |[fill=red!30]| 1 & |[fill=red!30]| 1 & |[fill=red!30]| 0 & 0\\
        0 & 0 & 0 & |[fill=red!30]| 1 & |[fill=red!30]| 1 & |[fill=red!30]| 1 & 0\\
        0 & 0 & 0 & 1 & 1 & 0 & 0\\
        0 & 0 & 1 & 1 & 0 & 0 & 0\\
        0 & 1 & 1 & 0 & 0 & 0 & 0\\
        1 & 1 & 0 & 0 & 0 & 0 & 0\\
    };
```

```
    \draw[very thick, red] (mtr-1-4.north west) rectangle (mtr-3-6.south east);

    \node [below= of mtr-5-4.south] (lm) {$\bf I$};

    \node[right = 0.2em of mtr] (str) {$*$};

    \matrix (K) [right=0.2em of str,matrix of nodes,row sep=-\pgflinewidth, nodes={draw, fill=blue!30}]
    {
        1 & 0 & 1 \\
        0 & 1 & 0 \\
        1 & 0 & 1 \\
    };
    \node [below = of K-3-2.south] (lk) {$\bf K$};

    \node [right = 0.2em of K] (eq) {$=$};

    \matrix (ret) [right=0.2em of eq,matrix of nodes,row sep=-\pgflinewidth, nodes={draw}]
    {
        1 & 4 & 3 & |[fill=green!30]| 4 & 1\\
        1 & 2 & 4 & 3 & 3\\
        1 & 2 & 3 & 4 & 1\\
        1 & 3 & 3 & 1 & 1\\
        3 & 3 & 1 & 1 & 0\\
    };
    \node [below = of ret-4-3.south] (lim) {${\bf I} * {\bf K}$};

    \draw[very thick, green] (ret-1-4.north west) rectangle (ret-1-4.south east);

    \draw[densely dotted, blue, thick] (mtr-1-4.north west) -- (K-1-1.north west);
    \draw[densely dotted, blue, thick] (mtr-3-4.south west) -- (K-3-1.south west);
    \draw[densely dotted, blue, thick] (mtr-1-6.north east) -- (K-1-3.north east);
    \draw[densely dotted, blue, thick] (mtr-3-6.south east) -- (K-3-3.south east);

    \draw[densely dotted, green, thick] (ret-1-4.north west) -- (K-1-1.north west);
    \draw[densely dotted, green, thick] (ret-1-4.south west) -- (K-3-1.south west);
    \draw[densely dotted, green, thick] (ret-1-4.north east) -- (K-1-3.north east);
    \draw[densely dotted, green, thick] (ret-1-4.south east) -- (K-3-3.south east);

    \matrix (K) [right=0.2em of str,matrix of nodes,row sep=-\pgflinewidth, nodes={draw, fill=blue!10}]
    {
        1 & 0 & 1 \\
        0 & 1 & 0 \\
        1 & 0 & 1 \\
    };

    \draw[very thick, blue] (K-1-1.north west) rectangle (K-3-3.south east);

    \node[anchor=south east, inner sep=0.01em, blue] at (mtr-1-4.south east) (xx) {\scalebox{.5}{$\times
        1$}};
    \node[anchor=south east, inner sep=0.01em, blue] at (mtr-1-5.south east) (xx) {\scalebox{.5}{$\times
        0$}};
    \node[anchor=south east, inner sep=0.01em, blue] at (mtr-1-6.south east) (xx) {\scalebox{.5}{$\times
        1$}};
    \node[anchor=south east, inner sep=0.01em, blue] at (mtr-2-4.south east) (xx) {\scalebox{.5}{$\times
        0$}};
    \node[anchor=south east, inner sep=0.01em, blue] at (mtr-2-5.south east) (xx) {\scalebox{.5}{$\times
        1$}};
    \node[anchor=south east, inner sep=0.01em, blue] at (mtr-2-6.south east) (xx) {\scalebox{.5}{$\times
        0$}};
    \node[anchor=south east, inner sep=0.01em, blue] at (mtr-3-4.south east) (xx) {\scalebox{.5}{$\times
        1$}};
    \node[anchor=south east, inner sep=0.01em, blue] at (mtr-3-5.south east) (xx) {\scalebox{.5}{$\times
        0$}};
    \node[anchor=south east, inner sep=0.01em, blue] at (mtr-3-6.south east) (xx) {\scalebox{.5}{$\times
        1$}};

\end{tikzpicture}
```

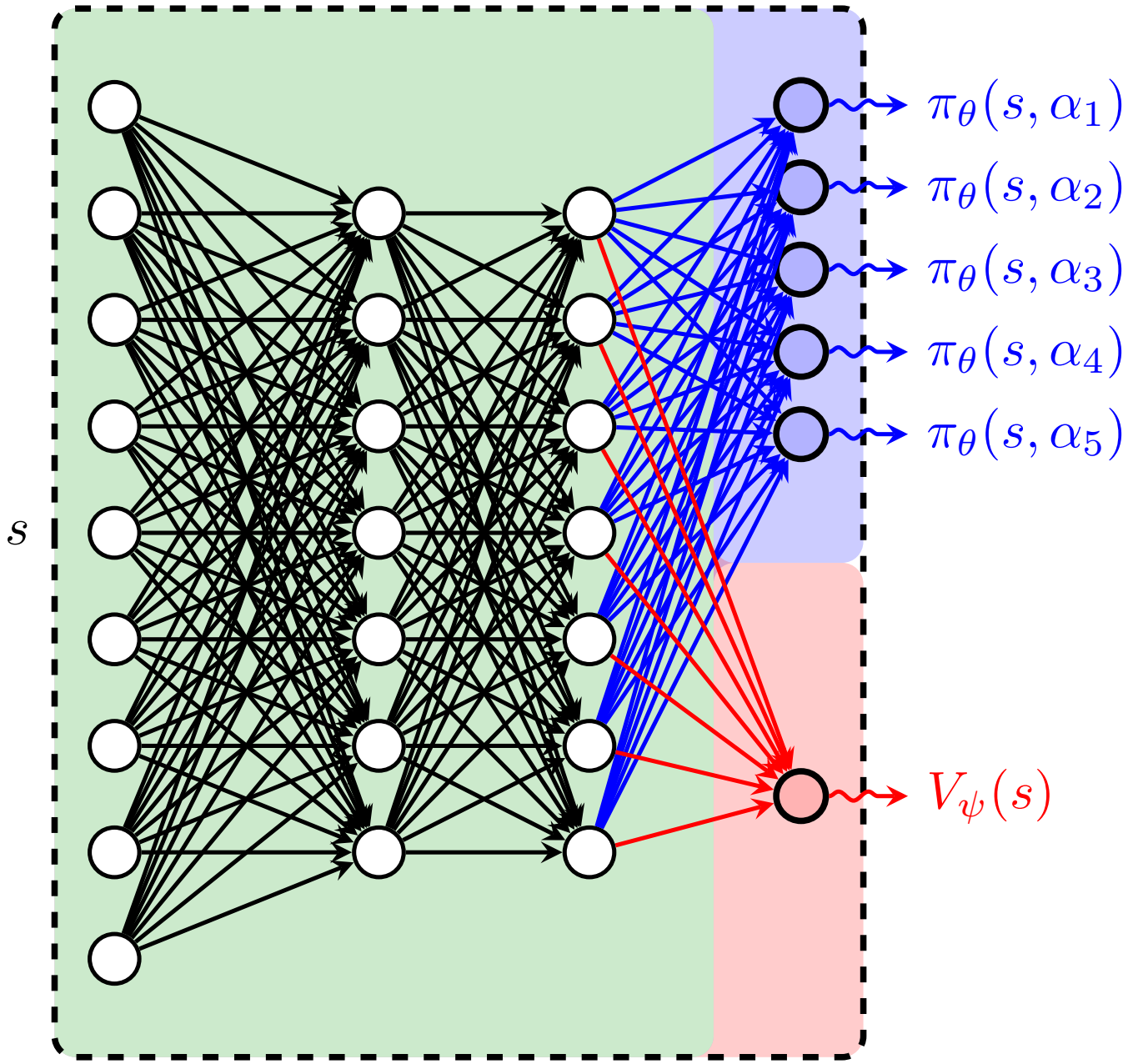
1.2 A3C execution




```
\begin{tikzpicture}

        \node[rounded rectangle, draw, thick, align=center] (A1) {Agent 1\\$(\theta_1', \psi_1')$};
        \node[rounded rectangle, draw, thick, right= of A1, align=center] (A2) {Agent 2\\$(\theta_2', \psi
            _2')$};
        \node[rounded rectangle, draw, thick, right= of A2, align=center] (A3) {Agent 3\\$(\theta_3', \psi
            _3')$};
        \node[right=0.4em of A3, align=center] (mid) {\dots};

        \node[rounded rectangle, draw, thick, right= of A3, align=center] (AN) {Agent $n$\\$(\theta_n', \
            psi_n')$};

        \node[rounded rectangle, draw, thick, yshift=8em, xshift=11.9em, align=center] (G) {Global state
            \\$(\theta, \psi)$};

        \node[rounded rectangle, draw, thick, below= of A1, align=center] (E1) {Env. 1\\$(\mathcal{T}, \
            mathcal{R})$};
        \node[rounded rectangle, draw, thick, below= of A2, align=center] (E2) {Env. 2\\$(\mathcal{T}, \
            mathcal{R})$};
        \node[rounded rectangle, draw, thick, below= of A3, align=center] (E3) {Env. 3\\$(\mathcal{T}, \
            mathcal{R})$};
        \node[rounded rectangle, draw, thick, below= of AN, align=center] (EN) {Env. $n$\\$(\mathcal{T}, \
            mathcal{R})$};

        \draw[-stealth, very thick] (G) -- node[above=0.5em] {copy} (A1);

        \foreach \x in {2,3,N}
                \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
                    post length=1.5mm}, decorate,very thick] ([xshift=-0.5em]A\x.south) -- node[left] {$a_t
                    $} ([xshift=-0.5em]E\x.north);
        \foreach \x in {2,3,N}
                \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
                    post length=1.5mm}, decorate,very thick] ([xshift=0.5em]E\x.north) -- node[right] {$r_t
                    , s_{t+1}$} ([xshift=0.5em]A\x.south);

        \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
            length=1.5mm}, decorate,very thick] (E1.north) -- node[right] {$s_0$} (A1.south);

        \node[rectangle split,
                minimum height=0.7cm,
                rectangle split horizontal,
                rectangle split parts=8,
                draw,
```

```
                anchor=center,
                left=2em of G,
                rectangle split part fill={white,white,white,white,white,white,white,gray}]
                (q1) {};

        \node[above=0.1em of q1] (N) {Queue};

        \draw[-stealth, very thick] (A1) -- node[left] {$(\Delta\theta, \Delta\psi)$} (q1);
        \draw[-stealth, very thick] (q1) -- node[above, xshift=-1em] {$+$} ([xshift=2.3em,yshift=-0.5em]G.
            west);

\end{tikzpicture}
```

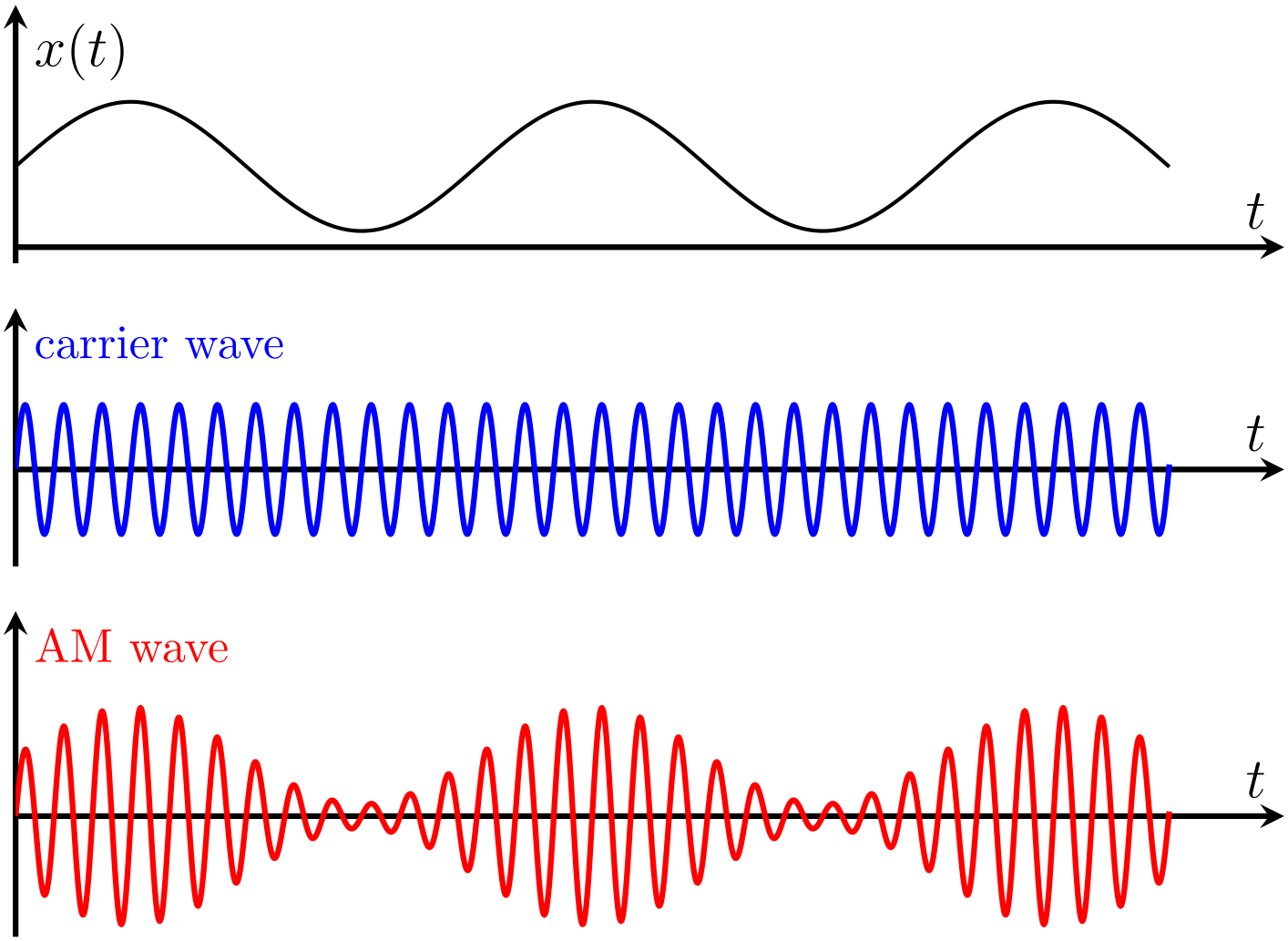
1.3 A3C Neural Network




```
\begin{tikzpicture}

        \path[rounded corners, fill=blue, fill opacity=0.2] (-0.4, 3.5) --  (-0.4, -3.5) -- (4, -3.5) --
            (4, -0.2) -- (5, -0.2) -- (5, 3.5) -- (-0.4, 3.5) -- (-0.4, 0);
        \path[rounded corners, fill=red, fill opacity=0.2] (-0.4, -3.5) --  (-0.4, 3.5) -- (4, 3.5) -- (4,
            -0.2) -- (5, -0.2) -- (5, -3.5) -- (-0.4, -3.5) -- (-0.4, 0);
        \path[rounded corners, fill=white] (-0.4, 0) -- (-0.4, -3.5) -- (4, -3.5) -- (4, 3.5) -- (-0.4,
            3.5) -- (-0.4, 0);
```

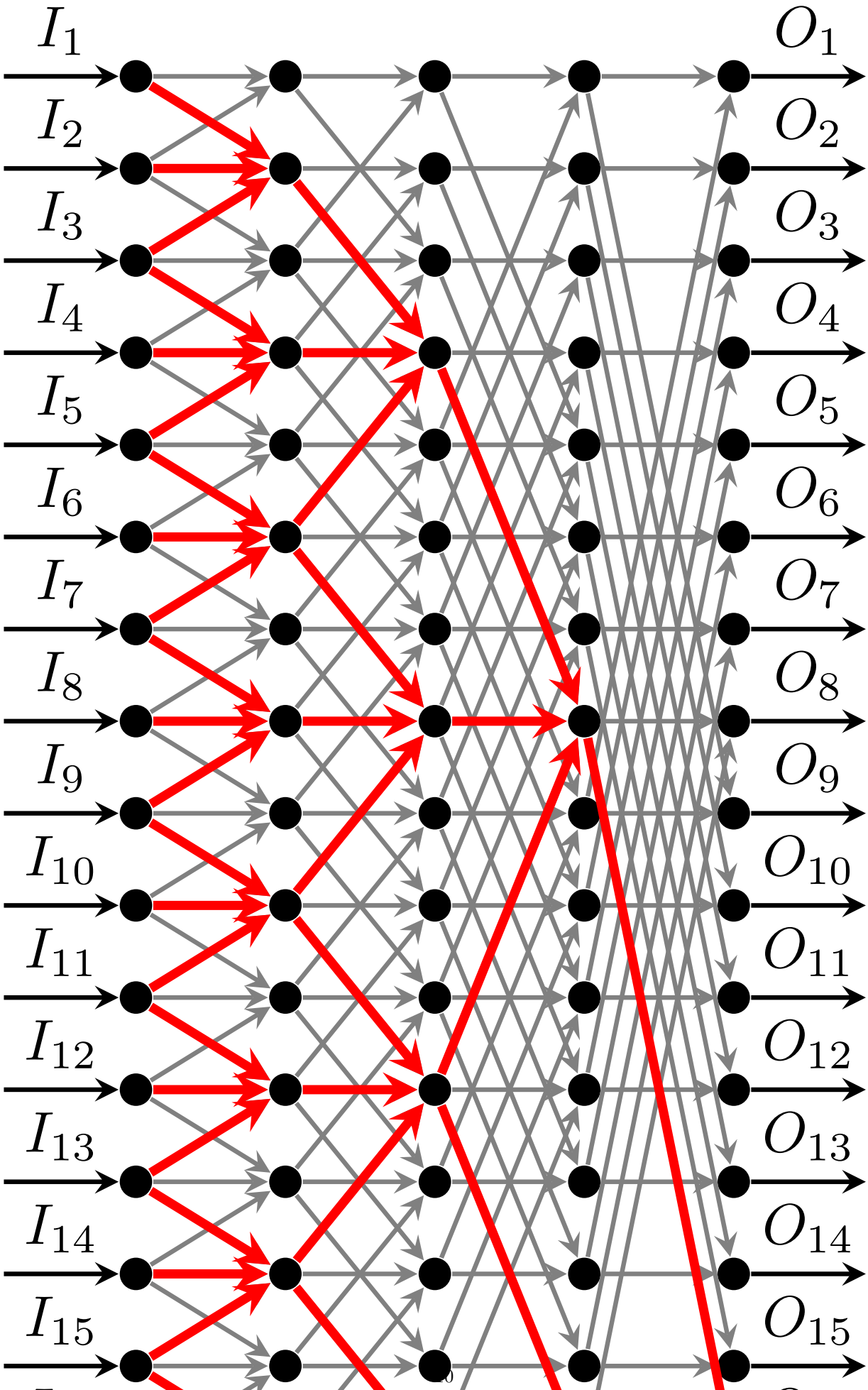
```
        \path[rounded corners, fill=olivegreen, fill opacity=0.2] (-0.4, 0) -- (-0.4, -3.5) -- (4, -3.5) --
             (4, 3.5) -- (-0.4, 3.5) -- (-0.4, 0);
        \path [draw, dashed, very thick, rectangle, rounded corners] (-0.4, 0) -- (-0.4, -3.5) -- (5, -3.5)
             -- (5, 3.5) -- (-0.4, 3.5) -- (-0.4, 0);

        \node[circle, thick, fill=white, draw] (x1) {};
        \node[circle, thick, draw, fill=white, below=1em of x1] (x2) {};
        \node[circle, thick, fill=white, draw, below=1em of x2] (x3) {};
        \node[circle, thick, fill=white, draw, below=1em of x3] (x4) {};
        \node[circle, thick, fill=white, draw, below=1em of x4] (x5) {};
        \node[circle, thick, fill=white, draw, above=1em of x1] (x6) {};
        \node[circle, thick, fill=white, draw, above=1em of x6] (x7) {};
        \node[circle, thick, fill=white, draw, above=1em of x7] (x8) {};
        \node[circle, thick, fill=white, draw, above=1em of x8] (x9) {};
        \node[circle, thick, right=4em of x1, fill=white, draw] (xhh1) {};
        \node[circle, thick, draw, fill=white, below=1em of xhh1] (xhh2) {};
        \node[circle, thick, fill=white, draw, below=1em of xhh2] (xhh3) {};
        \node[circle, thick, fill=white, draw, below=1em of xhh3] (xhh4) {};
        \node[circle, thick, fill=white, draw, above=1em of xhh1] (xhh5) {};
        \node[circle, thick, fill=white, draw, above=1em of xhh5] (xhh6) {};
        \node[circle, thick, fill=white, draw, above=1em of xhh6] (xhh7) {};
        \node[circle, thick, right=8em of x1, fill=white, draw] (xh1) {};
        \node[circle, thick, draw, fill=white, below=1em of xh1] (xh2) {};
        \node[circle, thick, fill=white, draw, below=1em of xh2] (xh3) {};
        \node[circle, thick, fill=white, draw, below=1em of xh3] (xh4) {};
        \node[circle, thick, fill=white, draw, above=1em of xh1] (xh5) {};
        \node[circle, thick, fill=white, draw, above=1em of xh5] (xh6) {};
        \node[circle, thick, fill=white, draw, above=1em of xh6] (xh7) {};
        \node[circle, very thick, fill=blue!30, draw, right=12em of x1, yshift=5em] (hm1) {};
        \node[circle, very thick, draw, fill=blue!30, below=0.5em of hm1] (hm2) {};
        \node[circle, very thick, draw, fill=blue!30, below=0.5em of hm2] (hm3) {};
        \node[circle, very thick, draw, fill=blue!30, above=0.5em of hm1] (hm4) {};
        \node[circle, very thick, draw, fill=blue!30, above=0.5em of hm4] (hm5) {};
        \node[circle, very thick, fill=red!30, draw, right=12em of x1, yshift=-5em] (hs1) {};
        \node[right=1.5em of hm1, blue] (mu1) {$\pi_\theta(s, \alpha_3)$};
        \node[right=1.5em of hm2, blue] (mu2) {$\pi_\theta(s, \alpha_4)$};
        \node[right=1.5em of hm3, blue] (mu3) {$\pi_\theta(s, \alpha_5)$};
        \node[right=1.5em of hm4, blue] (mu4) {$\pi_\theta(s, \alpha_2)$};
        \node[right=1.5em of hm5, blue] (mu5) {$\pi_\theta(s, \alpha_1)$};
        \node[right=1.5em of hs1, red] (s1) {$V_\psi(s)$};

        \foreach \x in {1,...,9}
                \foreach \y in {1,...,7}
                        \draw[-stealth, thick] (x\x) -- (xhh\y);

        \foreach \x in {1,...,7}
                \foreach \y in {1,...,7}
                        \draw[-stealth, thick] (xhh\x) -- (xh\y);

        \foreach \x in {1,...,7}
                \foreach \y in {1,...,5}
                        \draw[-stealth, thick, blue] (xh\x) -- (hm\y);

        \foreach \x in {1,...,7}
                \draw[-stealth, thick, red] (xh\x) -- (hs1);

        \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
            length=1.5mm}, decorate, thick, red] (hs1) -- (s1);

        \foreach \x in {1,...,5}
                \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
                    post length=1.5mm}, decorate, thick, blue] (hm\x) -- (mu\x);

        \node[left=0.75em of x1] (l1) {$s$};
\end{tikzpicture}
```

1.4 Amplitude Modulation




```
\begin{tikzpicture}[samples=1000, domain=0:10*pi]

        \begin{axis}[
                width=11cm, height=3.5cm,
                xtick=\empty,
                ytick=\empty,
                xlabel={\large $t$},
                ylabel={\large $x(t)$},
                xmin=0, xmax=11*pi,
                ymin=-0.5, ymax=7.5,
                axis lines = middle,
                very thick,
                trig format = rad
        ]
                \addplot [no markers, smooth, thick] {2.5 + 2*sin(0.5*x)};
        \end{axis}

        \begin{axis}[
                at={(0, -2.25cm)},
                width=11cm, height=3.5cm,
                xtick=\empty,
                ytick=\empty,
                xlabel={\large $t$},
                ylabel={\textcolor{blue}{carrier wave}},
                xmin=0, xmax=11*pi,
                ymin=-3, ymax=5,
                axis lines = middle,
                very thick,
                trig format = rad
        ]
                \addplot [no markers, smooth, blue, very thick] {2*sin(6*x)};
        \end{axis}
```

```
        \begin{axis}[
                at={(0, -5cm)},
                width=11cm, height=4cm,
                xtick=\empty,
                ytick=\empty,
                xlabel={\large $t$},
                ylabel={\textcolor{red}{AM wave}},
                xmin=0, xmax=11*pi,
                ymin=-10, ymax=17,
                axis lines = middle,
                very thick,
                trig format = rad
        ]
                \addplot [no markers, smooth, red, very thick] {(2.5 + 2*sin(0.5*x)) * 2*sin(6*x)};
        \end{axis}
\end{tikzpicture}
```

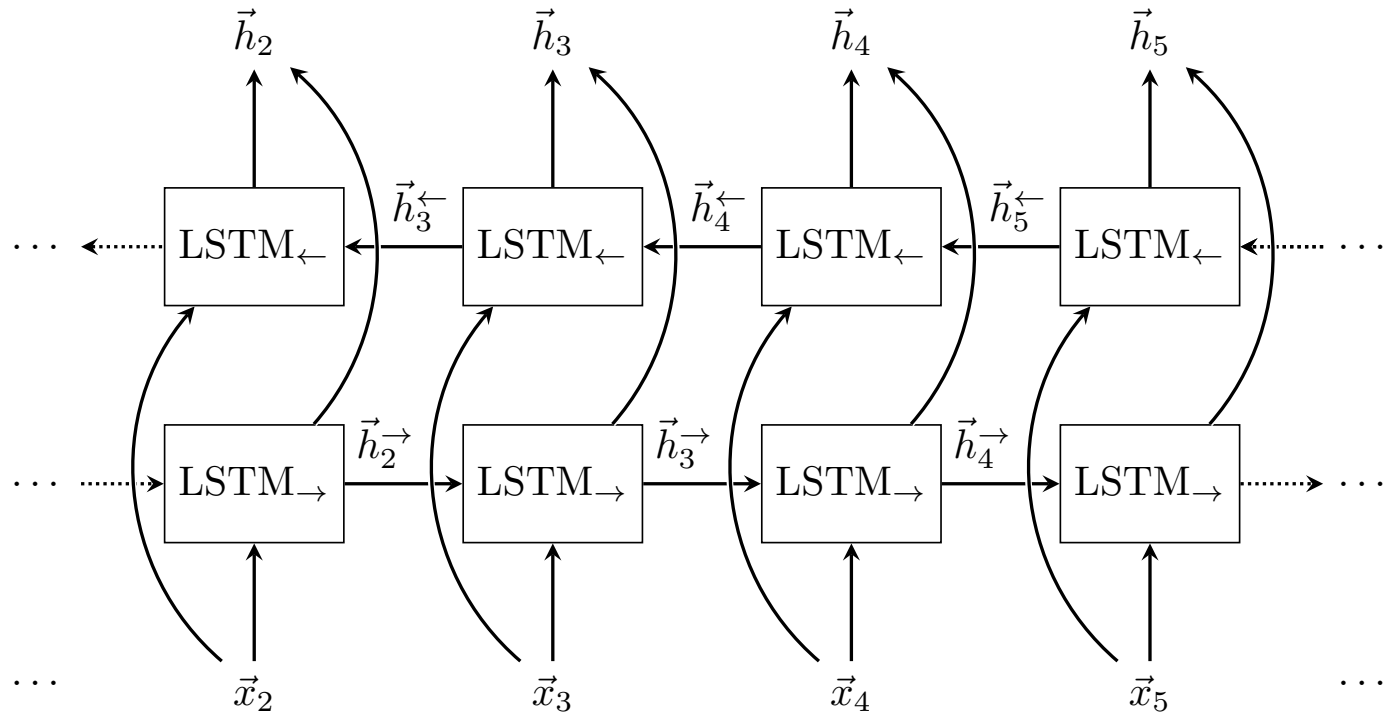

I_1
I_2
I_3
I_4
I_5
I_6
I_7
I_8
I_9
I_{10}
I_{11}
I_{12}
I_{13}
I_{14}
I_{15}
O_1
O_2
O_3
O_4
O_5
O_6
O_7
O_8
O_9
O_{10}
O_{11}
O_{12}
O_{13}
O_{14}
O_{15}

```
\begin{tikzpicture}

    \node[circle, fill, inner sep=0.2em] (s1) {};
    \node[circle, below=1em of s1, fill, inner sep=0.2em] (s2) {};
    \node[circle, below=1em of s2, fill, inner sep=0.2em] (s3) {};
    \node[circle, below=1em of s3, fill, inner sep=0.2em] (s4) {};
    \node[circle, below=1em of s4, fill, inner sep=0.2em] (s5) {};
    \node[circle, below=1em of s5, fill, inner sep=0.2em] (s6) {};
    \node[circle, below=1em of s6, fill, inner sep=0.2em] (s7) {};
    \node[circle, below=1em of s7, fill, inner sep=0.2em] (s8) {};
    \node[circle, below=1em of s8, fill, inner sep=0.2em] (s9) {};
    \node[circle, below=1em of s9, fill, inner sep=0.2em] (s10) {};
    \node[circle, below=1em of s10, fill, inner sep=0.2em] (s11) {};
    \node[circle, below=1em of s11, fill, inner sep=0.2em] (s12) {};
    \node[circle, below=1em of s12, fill, inner sep=0.2em] (s13) {};
    \node[circle, below=1em of s13, fill, inner sep=0.2em] (s14) {};
    \node[circle,below=1em of s14,  fill, inner sep=0.2em] (s15) {};
    \node[circle, below=1em of s15, fill, inner sep=0.2em] (s16) {};

    \foreach \x in {1,...,16}
        \node[circle, right=2em of s\x, fill, inner sep=0.2em] (h\x) {};
    \foreach \x in {1,...,16}
        \node[circle, right=2em of h\x, fill, inner sep=0.2em] (hh\x) {};
    \foreach \x in {1,...,16}
        \node[circle, right=2em of hh\x, fill, inner sep=0.2em] (hhh\x) {};
    \foreach \x in {1,...,16}
        \node[circle, right=2em of hhh\x, fill, inner sep=0.2em] (hhhh\x) {};
    \foreach \x in {1,...,16}
        \node[circle, right=2em of hhhh\x] (o\x) {};
    \foreach \x in {1,...,16}
        \node[circle, left=2em of s\x] (i\x) {};

    \foreach \x in {1,...,16}
        \draw[-stealth, thick] (i\x) --node[above] {$I_{\x}$} (s\x);
    \foreach \x in {1,...,16}
        \draw[-stealth, thick] (hhhh\x) --node[above] {$O_{\x}$} (o\x);
    \foreach \x in {1,...,16}
        \draw[-stealth, thick, gray] (s\x) -- (h\x);
    \foreach \x in {1,...,16}
        \draw[-stealth, thick, gray] (h\x) -- (hh\x);
    \foreach \x in {1,...,16}
        \draw[-stealth, thick, gray] (hh\x) -- (hhh\x);
    \foreach \x in {1,...,16}
        \draw[-stealth, thick, gray] (hhh\x) -- (hhhh\x);

    \draw[-stealth, thick, gray] (s1) -- (h2);
    \draw[-stealth, thick, gray] (s2) -- (h1);
    \draw[-stealth, thick, gray] (s2) -- (h3);
    \draw[-stealth, thick, gray] (s3) -- (h2);
    \draw[-stealth, thick, gray] (s3) -- (h4);
    \draw[-stealth, thick, gray] (s4) -- (h3);
    \draw[-stealth, thick, gray] (s4) -- (h5);
    \draw[-stealth, thick, gray] (s5) -- (h4);
    \draw[-stealth, thick, gray] (s5) -- (h6);
    \draw[-stealth, thick, gray] (s6) -- (h5);
    \draw[-stealth, thick, gray] (s6) -- (h7);
    \draw[-stealth, thick, gray] (s7) -- (h6);
    \draw[-stealth, thick, gray] (s7) -- (h8);
    \draw[-stealth, thick, gray] (s8) -- (h7);
    \draw[-stealth, thick, gray] (s8) -- (h9);
    \draw[-stealth, thick, gray] (s9) -- (h8);
    \draw[-stealth, thick, gray] (s9) -- (h10);
    \draw[-stealth, thick, gray] (s10) -- (h9);
    \draw[-stealth, thick, gray] (s10) -- (h11);
    \draw[-stealth, thick, gray] (s11) -- (h10);
    \draw[-stealth, thick, gray] (s11) -- (h12);
    \draw[-stealth, thick, gray] (s12) -- (h11);
    \draw[-stealth, thick, gray] (s12) -- (h13);
    \draw[-stealth, thick, gray] (s13) -- (h12);
    \draw[-stealth, thick, gray] (s13) -- (h14);
    \draw[-stealth, thick, gray] (s14) -- (h13);
    \draw[-stealth, thick, gray] (s14) -- (h15);
    \draw[-stealth, thick, gray] (s15) -- (h14);
    \draw[-stealth, thick, gray] (s15) -- (h16);
```

```
    \draw[-stealth, thick, gray] (s16) -- (h15);

    \draw[-stealth, thick, gray] (h1) -- (hh3);
    \draw[-stealth, thick, gray] (h2) -- (hh4);
    \draw[-stealth, thick, gray] (h3) -- (hh1);
    \draw[-stealth, thick, gray] (h3) -- (hh5);
    \draw[-stealth, thick, gray] (h4) -- (hh2);
    \draw[-stealth, thick, gray] (h4) -- (hh6);
    \draw[-stealth, thick, gray] (h5) -- (hh3);
    \draw[-stealth, thick, gray] (h5) -- (hh7);
    \draw[-stealth, thick, gray] (h6) -- (hh4);
    \draw[-stealth, thick, gray] (h6) -- (hh8);
    \draw[-stealth, thick, gray] (h7) -- (hh5);
    \draw[-stealth, thick, gray] (h7) -- (hh9);
    \draw[-stealth, thick, gray] (h8) -- (hh6);
    \draw[-stealth, thick, gray] (h8) -- (hh10);
    \draw[-stealth, thick, gray] (h9) -- (hh7);
    \draw[-stealth, thick, gray] (h9) -- (hh11);
    \draw[-stealth, thick, gray] (h10) -- (hh8);
    \draw[-stealth, thick, gray] (h10) -- (hh12);
    \draw[-stealth, thick, gray] (h11) -- (hh9);
    \draw[-stealth, thick, gray] (h11) -- (hh13);
    \draw[-stealth, thick, gray] (h12) -- (hh10);
    \draw[-stealth, thick, gray] (h12) -- (hh14);
    \draw[-stealth, thick, gray] (h13) -- (hh11);
    \draw[-stealth, thick, gray] (h13) -- (hh15);
    \draw[-stealth, thick, gray] (h14) -- (hh12);
    \draw[-stealth, thick, gray] (h14) -- (hh16);
    \draw[-stealth, thick, gray] (h15) -- (hh13);
    \draw[-stealth, thick, gray] (h16) -- (hh14);

    \draw[-stealth, thick, gray] (hh1) -- (hhh5);
    \draw[-stealth, thick, gray] (hh2) -- (hhh6);
    \draw[-stealth, thick, gray] (hh3) -- (hhh7);
    \draw[-stealth, thick, gray] (hh4) -- (hhh8);
    \draw[-stealth, thick, gray] (hh5) -- (hhh1);
    \draw[-stealth, thick, gray] (hh5) -- (hhh9);
    \draw[-stealth, thick, gray] (hh6) -- (hhh2);
    \draw[-stealth, thick, gray] (hh6) -- (hhh10);
    \draw[-stealth, thick, gray] (hh7) -- (hhh3);
    \draw[-stealth, thick, gray] (hh7) -- (hhh11);
    \draw[-stealth, thick, gray] (hh8) -- (hhh4);
    \draw[-stealth, thick, gray] (hh8) -- (hhh12);
    \draw[-stealth, thick, gray] (hh9) -- (hhh5);
    \draw[-stealth, thick, gray] (hh9) -- (hhh13);
    \draw[-stealth, thick, gray] (hh10) -- (hhh6);
    \draw[-stealth, thick, gray] (hh10) -- (hhh14);
    \draw[-stealth, thick, gray] (hh11) -- (hhh7);
    \draw[-stealth, thick, gray] (hh11) -- (hhh15);
    \draw[-stealth, thick, gray] (hh12) -- (hhh8);
    \draw[-stealth, thick, gray] (hh12) -- (hhh16);
    \draw[-stealth, thick, gray] (hh13) -- (hhh9);
    \draw[-stealth, thick, gray] (hh14) -- (hhh10);
    \draw[-stealth, thick, gray] (hh15) -- (hhh11);
    \draw[-stealth, thick, gray] (hh16) -- (hhh12);

    \draw[-stealth, thick, gray] (hhh1) -- (hhhh9);
    \draw[-stealth, thick, gray] (hhh2) -- (hhhh10);
    \draw[-stealth, thick, gray] (hhh3) -- (hhhh11);
    \draw[-stealth, thick, gray] (hhh4) -- (hhhh12);
    \draw[-stealth, thick, gray] (hhh5) -- (hhhh13);
    \draw[-stealth, thick, gray] (hhh6) -- (hhhh14);
    \draw[-stealth, thick, gray] (hhh7) -- (hhhh15);
    \draw[-stealth, thick, gray] (hhh8) -- (hhhh16);
    \draw[-stealth, thick, gray] (hhh9) -- (hhhh1);
    \draw[-stealth, thick, gray] (hhh10) -- (hhhh2);
    \draw[-stealth, thick, gray] (hhh11) -- (hhhh3);
    \draw[-stealth, thick, gray] (hhh12) -- (hhhh4);
    \draw[-stealth, thick, gray] (hhh13) -- (hhhh5);
    \draw[-stealth, thick, gray] (hhh14) -- (hhhh6);
    \draw[-stealth, thick, gray] (hhh15) -- (hhhh7);
    \draw[-stealth, thick, gray] (hhh16) -- (hhhh8);

    \draw[-stealth, ultra thick, red] (hhh16) -- (hhhh16);
    \draw[-stealth, ultra thick, red] (hhh8) -- (hhhh16);
```

```
    \draw[-stealth, ultra thick, red] (hh16) -- (hhh16);
    \draw[-stealth, ultra thick, red] (hh12) -- (hhh16);
    \draw[-stealth, ultra thick, red] (hh4) -- (hhh8);
    \draw[-stealth, ultra thick, red] (hh8) -- (hhh8);
    \draw[-stealth, ultra thick, red] (hh12) -- (hhh8);

    \draw[-stealth, ultra thick, red] (h16) -- (hh16);
    \draw[-stealth, ultra thick, red] (h14) -- (hh16);
    \draw[-stealth, ultra thick, red] (h14) -- (hh12);
    \draw[-stealth, ultra thick, red] (h12) -- (hh12);
    \draw[-stealth, ultra thick, red] (h10) -- (hh12);
    \draw[-stealth, ultra thick, red] (h10) -- (hh8);
    \draw[-stealth, ultra thick, red] (h8) -- (hh8);
    \draw[-stealth, ultra thick, red] (h6) -- (hh8);
    \draw[-stealth, ultra thick, red] (h6) -- (hh4);
    \draw[-stealth, ultra thick, red] (h4) -- (hh4);
    \draw[-stealth, ultra thick, red] (h2) -- (hh4);

    \draw[-stealth, ultra thick, red] (s16) -- (h16);
    \draw[-stealth, ultra thick, red] (s15) -- (h16);
    \draw[-stealth, ultra thick, red] (s15) -- (h14);
    \draw[-stealth, ultra thick, red] (s14) -- (h14);
    \draw[-stealth, ultra thick, red] (s13) -- (h14);
    \draw[-stealth, ultra thick, red] (s13) -- (h12);
    \draw[-stealth, ultra thick, red] (s12) -- (h12);
    \draw[-stealth, ultra thick, red] (s11) -- (h12);
    \draw[-stealth, ultra thick, red] (s11) -- (h10);
    \draw[-stealth, ultra thick, red] (s10) -- (h10);
    \draw[-stealth, ultra thick, red] (s9) -- (h10);
    \draw[-stealth, ultra thick, red] (s9) -- (h8);
    \draw[-stealth, ultra thick, red] (s8) -- (h8);
    \draw[-stealth, ultra thick, red] (s7) -- (h8);
    \draw[-stealth, ultra thick, red] (s7) -- (h6);
    \draw[-stealth, ultra thick, red] (s6) -- (h6);
    \draw[-stealth, ultra thick, red] (s5) -- (h6);
    \draw[-stealth, ultra thick, red] (s5) -- (h4);
    \draw[-stealth, ultra thick, red] (s4) -- (h4);
    \draw[-stealth, ultra thick, red] (s3) -- (h4);
    \draw[-stealth, ultra thick, red] (s3) -- (h2);
    \draw[-stealth, ultra thick, red] (s2) -- (h2);
    \draw[-stealth, ultra thick, red] (s1) -- (h2);

\end{tikzpicture}
```

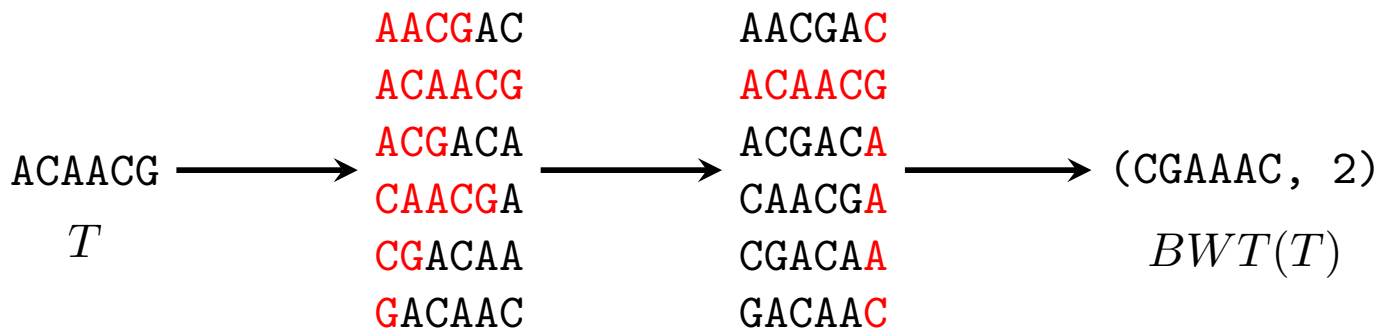
1.6 Bidirectional Long Short Term Memory




```
\begin{tikzpicture}
        \node[rectangle] (Y0) at (0, 0) {$\dots$};
        \node[rectangle, draw, right=2em of Y0, minimum height=1cm, minimum width=1cm] (RNN) {LSTM$_\
            rightarrow$};
        \node[rectangle, right=of RNN, draw, minimum height=1cm, minimum width=1cm] (RNN2) {LSTM$_\
            rightarrow$};
        \node[rectangle, right=of RNN2, draw, minimum height=1cm, minimum width=1cm] (RNN3) {LSTM$_\
            rightarrow$};

        \node[rectangle, right= of RNN3, draw, minimum height=1cm, minimum width=1cm] (RNN4) {LSTM$_\
            rightarrow$};
        \node[rectangle, right=2em of RNN4] (RNN5) {$\dots$};


        \node[rectangle, above=of RNN4, draw, minimum height=1cm, minimum width=1cm] (R25) {LSTM$_\
            leftarrow$};
        \node[rectangle, left=of R25, minimum height=1cm, minimum width=1cm, draw] (R24) {LSTM$_\leftarrow
            $};
        \node[rectangle, left=of R24, draw, minimum height=1cm, minimum width=1cm] (R23) {LSTM$_\leftarrow
            $};
        \node[rectangle, left=of R23, draw, minimum height=1cm, minimum width=1cm] (R22) {LSTM$_\leftarrow
            $};
        \node[rectangle, left=2em of R22] (R21) {$\dots$};
        \node[right=2em of R25] (Y20) {$\dots$};

        \node[below=of RNN] (X1) {$\vec{x}_2$};
        \node[below=of RNN2] (X2) {$\vec{x}_3$};
        \node[below=of RNN3] (X3) {$\vec{x}_4$};
        \node[below=of RNN4] (X4) {$\vec{x}_5$};
        \node[above=of R25] (Y5) {$\vec{h}_5$};
        \node[above=of R24] (Y4) {$\vec{h}_4$};
        \node[above=of R23] (Y3) {$\vec{h}_3$};
        \node[above=of R22] (Y2) {$\vec{h}_2$};

        \draw[-stealth, thick] (X1) -- (RNN);
        \draw[-stealth, thick] (X2) -- (RNN2);
        \draw[-stealth, thick] (X3) -- (RNN3);
        \draw[-stealth, thick] (X4) -- (RNN4);
        \draw[-stealth, thick, densely dotted] (Y0) -- (RNN);
        \draw[-stealth, thick] (RNN) -- node[above, pos=0.35] {$\vec{h}_2^\rightarrow$} (RNN2);
        \draw[-stealth, thick] (RNN2) -- node[above, pos=0.35] {$\vec{h}_3^\rightarrow$} (RNN3);
        \draw[-stealth, thick] (RNN3) -- node[above, pos=0.35] {$\vec{h}_4^\rightarrow$} (RNN4);
        \draw[-stealth, densely dotted, thick] (RNN4) -- (RNN5);
        \node[below=4em of Y0] (d) {\dots};
```

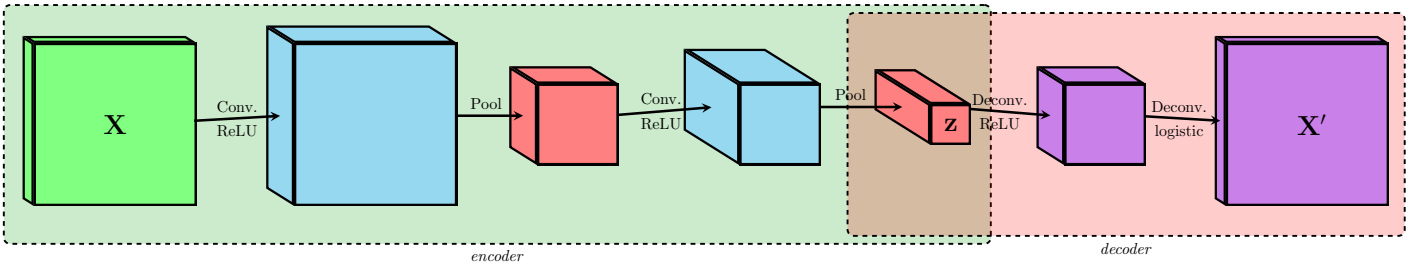
```
        \node[below=4em of RNN5] (d) {\dots};

        \path[-stealth, ultra thick, white] (X1) edge[bend left=45] (R22);
        \path[-stealth, thick] (X1) edge[bend left=45] (R22);
        \path[-stealth, ultra thick, white] (X2) edge[bend left=45] (R23);
        \path[-stealth, thick] (X2) edge[bend left=45] (R23);
        \path[-stealth, ultra thick, white] (X3) edge[bend left=45] (R24);
        \path[-stealth, thick] (X3) edge[bend left=45] (R24);
        \path[-stealth, ultra thick, white] (X4) edge[bend left=45] (R25);
        \path[-stealth, thick] (X4) edge[bend left=45] (R25);
        \draw[-stealth, densely dotted, thick] (Y20) -- (R25);

        \draw[-stealth, thick] (R22) -- (Y2);
        \draw[-stealth, thick] (R23) -- (Y3);
        \draw[-stealth, thick] (R24) -- (Y4);
        \draw[-stealth, thick] (R25) -- (Y5);

        \draw[stealth-, densely dotted, thick] (R21) -- (R22);
        \draw[stealth-, thick] (R22) -- node[above, pos=0.65] {$\vec{h}_3^\leftarrow$} (R23);
        \draw[stealth-, thick] (R23) -- node[above, pos=0.65] {$\vec{h}_4^\leftarrow$} (R24);
        \draw[stealth-, thick] (R24) -- node[above, pos=0.65] {$\vec{h}_5^\leftarrow$} (R25);
        \draw[-stealth, densely dotted, thick] (Y20) -- (R25);

        \path[-stealth, ultra thick, white] (RNN) edge[bend right=45] (Y2);
        \path[-stealth, thick] (RNN) edge[bend right=45] (Y2);
        \path[-stealth, ultra thick, white] (RNN2) edge[bend right=45] (Y3);
        \path[-stealth, thick] (RNN2) edge[bend right=45] (Y3);
        \path[-stealth, ultra thick, white] (RNN3) edge[bend right=45] (Y4);
        \path[-stealth, thick] (RNN3) edge[bend right=45] (Y4);
        \path[-stealth, ultra thick, white] (RNN4) edge[bend right=45] (Y5);
        \path[-stealth, thick] (RNN4) edge[bend right=45] (Y5);

\end{tikzpicture}
```

1.7 BWT




```
\begin{tikzpicture}[font=\tt]
        \node (T) at (0, 0) {ACAACG};
        \node[below=0.5mm of T] (c1) {$T$};
        \node[align=center] (tbl1) at (2.7, 0) {\textcolor{red}{AACG}AC\\\textcolor{red}{ACAACG}\\\
            textcolor{red}{ACG}ACA\\\textcolor{red}{CAACG}A\\\textcolor{red}{CG}ACAA\\\textcolor{red}{G}
            ACAAC};
        \node[align=center] (tbl2) at (5.4, 0) {AACGA\textcolor{red}{C}\\\textcolor{red}{ACAACG}\\ACGAC\
            textcolor{red}{A}\\CAACG\textcolor{red}{A}\\CGACA\textcolor{red}{A}\\GACAA\textcolor{red}{C}};
        \node[align=left] (BWT) at (8.6, 0) {(CGAAAC, 2)};
        \node[below=0.5mm of BWT] (c2) {$BWT(T)$};

        \draw[-stealth, very thick] (T) -- (tbl1);
        \draw[-stealth, very thick] (tbl1) -- (tbl2);
        \draw[-stealth, very thick] (tbl2) -- (BWT);
\end{tikzpicture}
```

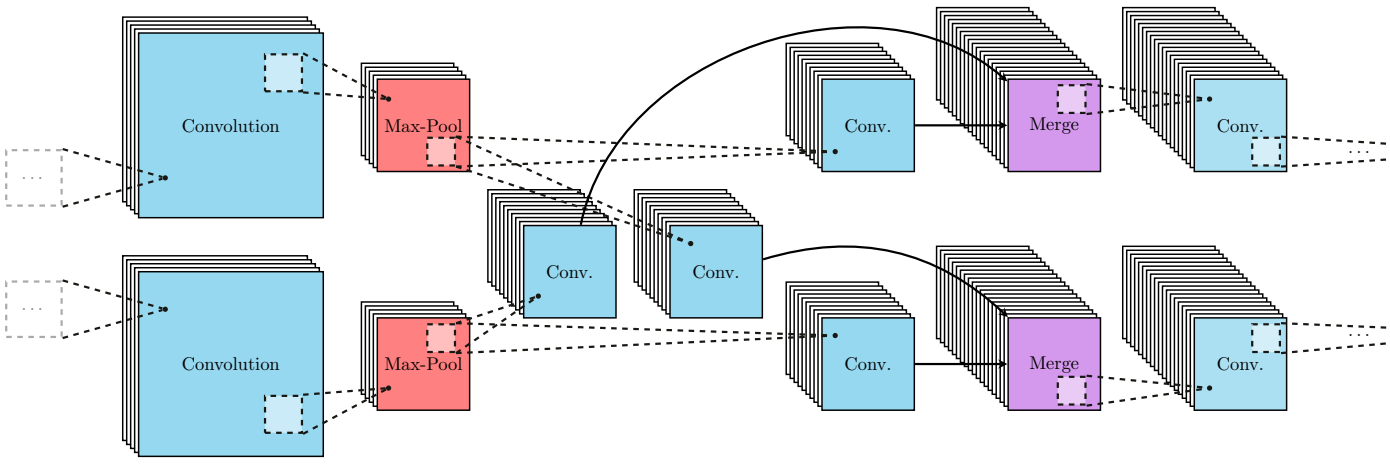
1.8 Convolutional Autoencoder




```
\definecolor{echoreg}{HTML}{2cb1e1}
\definecolor{olivegreen}{rgb}{0,0.6,0}
\definecolor{mymauve}{rgb}{0.58,0,0.82}


\newtoggle{redraw}
\newtoggle{redraw2}

\tikzset{%
pics/cube/.style args={#1/#2/#3/#4}{code={%
        \begin{scope}[line width=#4mm]
        \begin{scope}
        \clip (-#1,-#2,0) -- (#1,-#2,0) -- (#1,#2,0) -- (-#1,#2,0) -- cycle;
        \filldraw (-#1,-#2,0) -- (#1,-#2,0) -- (#1,#2,0) -- (-#1,#2,0) -- cycle;
        \end{scope}
\iftoggle{redraw}{%
}{%
        \begin{scope}
        \clip (-#1,-#2,0) -- (-#1-#3,-#2,-#3) -- (-#1-#3,#2,-#3) -- (-#1,#2,0) -- cycle;
        \filldraw (-#1,-#2,0) -- (-#1-#3,-#2,-#3) -- (-#1-#3,#2,-#3) -- (-#1,#2,0) -- cycle;
        \end{scope}
}
\iftoggle{redraw2}{%
}{
        \begin{scope}
        \clip (-#1,#2,0) -- (-#1-#3,#2,-#3) -- (#1-#3,#2,-#3) -- (#1,#2,0) -- cycle;
        \filldraw (-#1,#2,0) -- (-#1-#3,#2,-#3) -- (#1-#3,#2,-#3) -- (#1,#2,0) -- cycle;
        \end{scope}
}
        \node[inner sep=0] (-A) at (-#1-#3*0.5, 0, -#3*0.5) {};
        \node[inner sep=0] (-B) at (#1-#3*0.5, 0, -#3*0.5) {};

        \coordinate (-V) at (#1, #2);
        \coordinate (-W) at (#1, -#2);
        \end{scope}
}}}

\begin{tikzpicture}

        \node (1) [draw, dashed, minimum height=15em, minimum width=62em, xshift=24em, fill=olivegreen,
            fill opacity=0.2, very thick, rectangle, rounded corners] {};
                \node (la1) [below=0em of 1] {{\emph{encoder}}};
        \node (2) [draw, dashed, minimum height=14em, fill = red, fill opacity=0.2,minimum width=35em,
            xshift=63.5em, very thick, rectangle, rounded corners] {};
                \node (la1) [below=0em of 2] {{\emph{decoder}}};

        \node[] (i2) {};
        \pic[fill=green!50] (I2) {cube={1.8/1.8/0.4/1}};

        \togglefalse{redraw}
        \togglefalse{redraw2}

        \node[right=16em of i2] (y) {};

        \pic[right=16em of i2, fill=echoreg!50] (Y) {cube={1.8/1.8/1/1}};

        \node[right=12em of y] (y1) {};
        \pic[right=12em of y, fill=red!50] (Y1) {cube={0.9/0.9/1/1}};

        \node[right=12em of y1] (y2) {};
        \pic[right=12em of y1, fill=echoreg!50] (Y2) {cube={0.9/0.9/2/1}};
        \node[right=10em of y2] (y3) {};
```

```
        \pic[right=10em of y2, fill=red!50] (Y3) {cube={0.45/0.45/2/1}};

        \node[right=9em of y3] (z1) {};
        \pic[right=9em of y3, fill=mymauve!50] (Z1) {cube={0.9/0.9/1/1}};

        \node[right=12em of z1] (z2) {};
        \pic[right=12em of z1, fill=mymauve!50] (Z2) {cube={1.8/1.8/0.4/1}};

        \draw [-stealth, ultra thick] (I2-B) -- node[above] {Conv.} node[below] {ReLU} (Y-A);

        \draw [-stealth, ultra thick] (Y-B) -- node[above] {Pool} (Y1-A);

        \draw [-stealth, ultra thick] (Y1-B) -- node[above=0.3em, inner sep=0.1em] {Conv.} node[below] {
            ReLU} (Y2-A);

        \draw [-stealth, ultra thick] (Y2-B) -- node[above] {Pool} (Y3-A);


        \draw [-stealth, ultra thick] (Y3-B) -- node[above] {Deconv.} node[below] {ReLU} (Z1-A);

        \draw [-stealth, ultra thick] (Z1-B) -- node[above] {Deconv.} node[below] {logistic} (Z2-A);


        \color{black}

        \toggletrue{redraw}
        \toggletrue{redraw2}

        \node[right=16em of i2] (y) {};
        \pic[right=16em of i2, fill=echoreg!50] (Y) {cube={1.8/1.8/1/1}};

        \pic[right=12em of y, fill=red!50] (Y1) {cube={0.9/0.9/1/1}};

        \pic[right=12em of y1, fill=echoreg!50] (Y2) {cube={0.9/0.9/2/1}};

        \pic[right=9em of y3, fill=mymauve!50] (Z1) {cube={0.9/0.9/1/1}};

        \togglefalse{redraw2}

        \pic[right=10em of y2, fill=red!50] (Y3) {cube={0.45/0.45/2/1}};

        \toggletrue{redraw2}

        \node[] (i2) {\LARGE ${\bf X}$};
        \node[right=9.25em of y2] (y3) {\LARGE ${\bf z}$};
        \node[right=11em of z1] (z2) {\LARGE ${\bf X}'$};

\end{tikzpicture}
```

1.9 Convolutional Coross-connection




```
\usetikzlibrary{arrows,decorations.pathmorphing,backgrounds,positioning,fit,petri, decorations.
    pathreplacing,shadows,calc}
```

```
\definecolor{echoreg}{HTML}{2cb1e1}
\definecolor{sublimedg}{HTML}{171813}
\definecolor{lgry}{HTML}{aaaaaa}
\definecolor{mymauve}{rgb}{0.58,0,0.82}

\tikzset{%
  cascaded/.style = {%
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -2ex,
      shadow yshift = 2ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -1.5ex,
      shadow yshift = 1.5ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -1ex,
      shadow yshift = 1ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -.5ex,
      shadow yshift = .5ex,
      draw=black,
      thick,
      fill = white},
    fill = white,
    draw,
    thick}}

\tikzset{%
  cascadedd/.style = {%
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -4.5ex,
      shadow yshift = 4.5ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -4ex,
      shadow yshift = 4ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -3.5ex,
      shadow yshift = 3.5ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -3ex,
      shadow yshift = 3ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -2.5ex,
      shadow yshift = 2.5ex,
      draw=black,
      thick,
```

```
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -2ex,
      shadow yshift = 2ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -1.5ex,
      shadow yshift = 1.5ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -1ex,
      shadow yshift = 1ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -.5ex,
      shadow yshift = .5ex,
      draw=black,
      thick,
      fill = white},
    fill = white,
    draw,
    thick}}

\tikzset{%
  cascadeddd/.style = {%
        general shadow = {%
      shadow scale = 1,
      shadow xshift = -9ex,
      shadow yshift = 9ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -8.5ex,
      shadow yshift = 8.5ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -8ex,
      shadow yshift = 8ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -7.5ex,
      shadow yshift = 7.5ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -7ex,
      shadow yshift = 7ex,
      draw=black,
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -6.5ex,
      shadow yshift = 6.5ex,
      draw=black,
      thick,
```

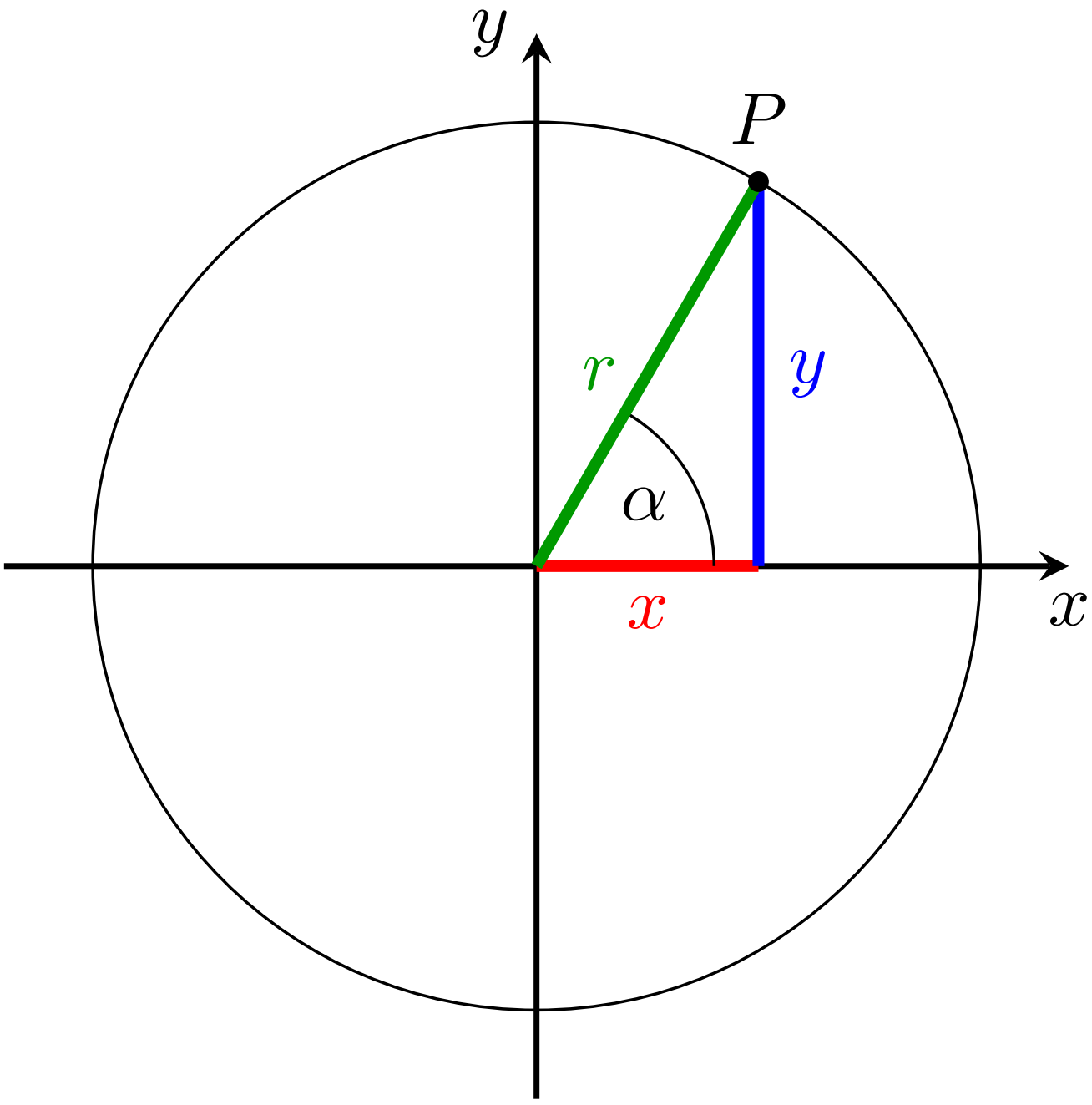
```
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -6ex,
    shadow yshift = 6ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -5.5ex,
    shadow yshift = 5.5ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -5ex,
    shadow yshift = 5ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -4.5ex,
    shadow yshift = 4.5ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -4ex,
    shadow yshift = 4ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -3.5ex,
    shadow yshift = 3.5ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -3ex,
    shadow yshift = 3ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -2.5ex,
    shadow yshift = 2.5ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -2ex,
    shadow yshift = 2ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -1.5ex,
    shadow yshift = 1.5ex,
    draw=black,
    thick,
    fill = white},
  general shadow = {%
    shadow scale = 1,
    shadow xshift = -1ex,
    shadow yshift = 1ex,
    draw=black,
```

```
      thick,
      fill = white},
    general shadow = {%
      shadow scale = 1,
      shadow xshift = -.5ex,
      shadow yshift = .5ex,
      draw=black,
      thick,
      fill = white},
    fill = white,
    draw,
    thick}}

\begin{tikzpicture}

        \node [cascaded,
        fill = echoreg!50,
    minimum width = 10em,
    minimum height = 10em] (Conv1C) {Convolution};
        \node [cascaded,
        fill = echoreg!50,
    minimum width = 10em,
    minimum height = 10em,
        below= of Conv1C] (Conv1M) {Convolution};


        \node [cascaded,
        fill = red!50,
    minimum width = 5em,
    minimum height = 5em,right= of Conv1C] (Pool1C) {Max-Pool};
        \node [cascaded,
        fill = red!50,
    minimum width = 5em,
    minimum height = 5em,right= of Conv1M] (Pool1M) {Max-Pool};

    \node [cascadedd,
        fill = echoreg!50,
    minimum width = 5em,
    minimum height = 5em, below right= of Pool1C] (Conv2CM) {Conv.};
        \node [cascadedd,
        fill = echoreg!50,
    minimum width = 5em,
    minimum height = 5em,right= of Conv2CM] (Conv2MC) {Conv.};

    \node [cascadedd,
        fill = echoreg!50,
    minimum width = 5em,
    minimum height = 5em, right= 19em of Pool1C] (Conv3C) {Conv.};
        \node [cascadedd,
        fill = echoreg!50,
    minimum width = 5em,
    minimum height = 5em, right = 19em of Pool1M] (Conv3M) {Conv.};


    \node [cascadeddd,
        fill = mymauve!40,
    minimum width = 5em,
    minimum height = 5em, right= 5em of Conv3C] (Conv4C) {Merge};
        \node [cascadeddd,
        fill = mymauve!40,
    minimum width = 5em,
    minimum height = 5em, right = 5em of Conv3M] (Conv4M) {Merge};

     \node [cascadeddd,
        fill = echoreg!40,
    minimum width = 5em,
    minimum height = 5em, right=5em of Conv4C] (DeconvC) {Conv.};

        \node [cascadeddd,
        fill = echoreg!40,
    minimum width = 5em,
    minimum height = 5em, right =5em of Conv4M] (DeconvM) {Conv.};

    \node[rectangle, dashed, draw=lgry, fill=white,  fill opacity=0.5, very thick, minimum width=3em,
        minimum height=3em] (R1C) at (-3.75, -1) {\textcolor{black}{\dots}};
```

```
\node[rectangle, dashed, draw=lgry, fill=white,  fill opacity=0.5, very thick, minimum width=3em,
    minimum height=3em] (R1M) at (-3.75, -3.5) {\textcolor{black}{\dots}};

\node[rectangle, dashed, draw=sublimedg, fill=white,  fill opacity=0.5,very thick, minimum width=2em,
    minimum height=2em] (R2C) at (1, 1) {};

\node[rectangle, dashed, draw=sublimedg, fill=white,  fill opacity=0.5,very thick, minimum width=2em,
    minimum height=2em] (R2M) at (1,-5.5) {};


\node[rectangle, dashed, draw=sublimedg, fill=white,  fill opacity=0.5,very thick, minimum width=1.5em,
     minimum height=1.5em] (R3C) at (4, -0.5) {};

\node[rectangle, dashed, draw=sublimedg, fill=white,  fill opacity=0.5,very thick, minimum width=1.5em,
     minimum height=1.5em] (R3M) at (4,-4.05) {};

\node[rectangle, dashed, draw=sublimedg, fill=white,  fill opacity=0.5,very thick, minimum width=1.5em,
     minimum height=1.5em] (R4C) at (16, .5) {};

\node[rectangle, dashed, draw=sublimedg, fill=white,  fill opacity=0.5,very thick, minimum width=1.5em,
     minimum height=1.5em] (R4M) at (16,-5.05) {};

\node[rectangle, dashed, draw=sublimedg, fill=white,  fill opacity=0.5,very thick, minimum width=1.5em,
     minimum height=1.5em] (R5C) at (19.7, -.5) {};

\node[rectangle, dashed, draw=sublimedg, fill=white,  fill opacity=0.5,very thick, minimum width=1.5em,
     minimum height=1.5em] (R5M) at (19.7, -4.05) {};

\node[circle, inner sep = 0.1em, fill=sublimedg] (C1C) at (-1.25, -1) {};
\node[circle, inner sep = 0.1em, fill=sublimedg] (C1M) at (-1.25, -3.5) {};

\node[circle, inner sep = 0.1em, fill=sublimedg] (C2C) at (3, 0.5) {};
\node[circle, inner sep = 0.1em, fill=sublimedg] (C2M) at (3, -5) {};

\node[circle, inner sep = 0.1em, fill=sublimedg] (C3MC) at (5.85, -3.25) {};
\node[circle, inner sep = 0.1em, fill=sublimedg] (C3CM) at (8.75, -2.25) {};

\node[circle, inner sep = 0.1em, fill=sublimedg] (C4C) at (11.5, -0.5) {};
\node[circle, inner sep = 0.1em, fill=sublimedg] (C4M) at (11.5, -4) {};

\node[circle, inner sep = 0.1em, fill=sublimedg] (C5C) at (18.625, 0.5) {};
\node[circle, inner sep = 0.1em, fill=sublimedg] (C5M) at (18.625, -5) {};

\draw[very thick, sublimedg, dashed] (R1C.north east) -- (C1C);
\draw[very thick, sublimedg, dashed] (R1C.south east) -- (C1C);
\draw[very thick, sublimedg, dashed] (R1M.north east) -- (C1M);
\draw[very thick, sublimedg, dashed] (R1M.south east) -- (C1M);

\draw[very thick, sublimedg, dashed] (R2C.north east) -- (C2C);
\draw[very thick, sublimedg, dashed] (R2C.south east) -- (C2C);
\draw[very thick, sublimedg, dashed] (R2M.north east) -- (C2M);
\draw[very thick, sublimedg, dashed] (R2M.south east) -- (C2M);

\draw[very thick, sublimedg, dashed] (R3C.north east) -- (C3CM);
\draw[very thick, sublimedg, dashed] (R3C.south east) -- (C3CM);
\draw[very thick, sublimedg, dashed] (R3M.north east) -- (C3MC);
\draw[very thick, sublimedg, dashed] (R3M.south east) -- (C3MC);

\draw[very thick, sublimedg, dashed] (R3C.north east) -- (C4C);
\draw[very thick, sublimedg, dashed] (R3C.south east) -- (C4C);
\draw[very thick, sublimedg, dashed] (R3M.north east) -- (C4M);
\draw[very thick, sublimedg, dashed] (R3M.south east) -- (C4M);

\draw[very thick, sublimedg, dashed] (R4C.north east) -- (C5C);
\draw[very thick, sublimedg, dashed] (R4C.south east) -- (C5C);
\draw[very thick, sublimedg, dashed] (R4M.north east) -- (C5M);
\draw[very thick, sublimedg, dashed] (R4M.south east) -- (C5M);

\draw[very thick, sublimedg, dashed] (R5C.north east) -- (22, -0.35);
\draw[very thick, sublimedg, dashed] (R5C.south east) -- (22, -0.65);
\draw[very thick, sublimedg, dashed] (R5M.north east) -- (22, -3.85);
\draw[very thick, sublimedg, dashed] (R5M.south east) -- (22, -4.15);

\node[] (da) at (21.5, -0.5) {\textcolor{lgry}\bf\dots};
\node[] (db) at (21.5, -4) {\textcolor{lgry}\bf\dots};
```

```
    \path[very thick, -stealth] (Conv2CM) edge[bend left=60] (Conv4C);
    \draw[very thick, -stealth] (Conv3C) -- (Conv4C);
    \path[very thick, -stealth] (Conv2MC) edge[bend left] (Conv4M);
    \draw[very thick, -stealth] (Conv3M) -- (Conv4M);
\end{tikzpicture}
```

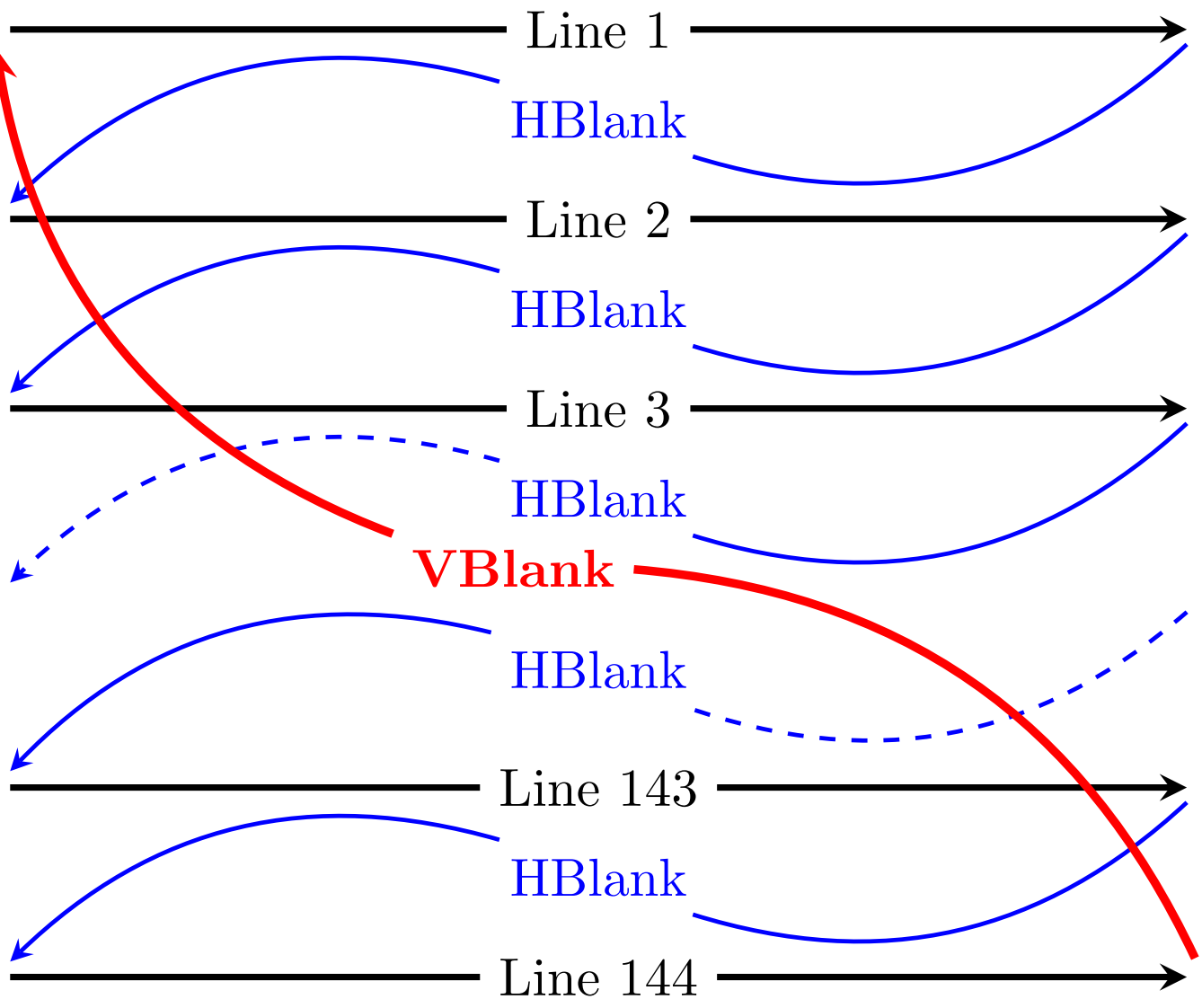
1.10 Coordinate Systems




```
\definecolor{olivegreen}{rgb}{0,0.6,0}

\begin{tikzpicture}[scale=0.85]
        % Axis
        \draw[thick,-stealth,black] (-3,0)--(3,0) coordinate (A) node[below] {$x$}; % x axis
        \draw[thick,-stealth,black] (0,-3)--(0,3) node[left] {$y$}; % y axis
        \draw[black,thin] (0,0) circle (2.5cm);

        \draw[ultra thick,red] (0,0) -- (60:2.5cm |- 0,0) node[midway,below] {$x$}; % UpOn y axis

        \draw (1,0) arc (0:60:1) node at ($(60/2:0.7)$) {$\alpha$};
        \draw[ultra thick, blue] (60:2.5cm) -- (60:2.5cm |- 0,0) node[midway,right] {$y$}; % vertical line
```

```
        \draw[ultra thick,olivegreen,rotate=60] (0,0) -- node [left] {$r$} (2.5,0) coordinate (B);

        \draw[xshift=-1cm] (B) node[circle,fill,inner sep=1pt,label=above:$P$](e){};
\end{tikzpicture}
```

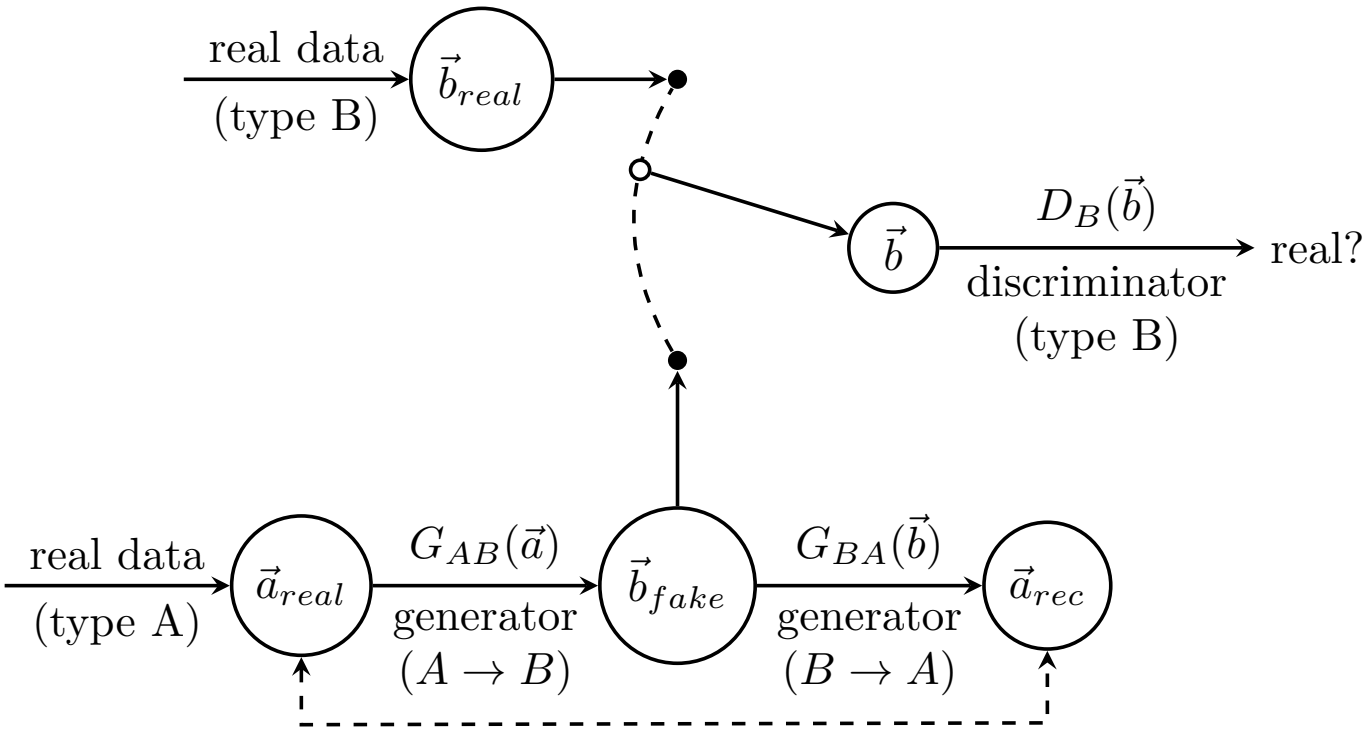
1.11 CRT Rendering




```
\begin{tikzpicture}[node distance=4cm, auto]
        \node (00) {};
        \node [right of=00] (l1) {Line 1};
        \node [right of=l1] (01) {};
        \draw[-stealth, very thick] (00) -- (l1) -- (01);
        \node [below =1cm of 00] (10) {};
        \node [right of=10] (l2) {Line 2};
        \node [right of=l2] (11) {};
        \draw[-stealth, very thick] (10) -- (l2) -- (11);
        \node [below =1cm of 10] (20) {};
        \node [right of=20] (l3) {Line 3};
        \node [right of=l3] (21) {};
        \draw[-stealth, very thick] (20) -- (l3) -- (21);

        \node [below =1cm of 20] (30) {};
        \node [right of=30] (l4) {};
        \node [right of=l4] (31) {};

        \node [below =1cm of 30] (1430) {};
        \node [right of=1430] (l143) {Line 143};
        \node [right of=l143] (1431) {};
```

```
        \draw[-stealth, very thick] (1430) -- (1143) -- (1431);
        \node [below =1cm of 1430] (1440) {};
        \node [right of=1440] (1144) {Line 144};
        \node [right of=1144] (1441) {};
        \draw[-stealth, very thick] (1440) -- (1144) -- (1441);

        \node [below=0.1cm of 11] (h1) {\textcolor{blue}{HBlank}};
        \draw [thick, blue] (01) [bend left] to (h1);
        \draw [-stealth, thick, blue] (h1) [bend right] to (10);

        \node [below=0.1cm of 12] (h2) {\textcolor{blue}{HBlank}};
        \draw [thick, blue] (11) [bend left] to (h2);
        \draw [-stealth, thick, blue] (h2) [bend right] to (20);

        \node [below=0.1cm of 13] (h3) {\textcolor{blue}{HBlank}};
        \draw [thick, blue] (21) [bend left] to (h3);
        \draw [-stealth, thick, blue, dashed] (h3) [bend right] to (30);

        \node [below=0.1cm of 14] (h4) {\textcolor{blue}{HBlank}};
        \draw [thick, blue, dashed] (31) [bend left] to (h4);
        \draw [-stealth, thick, blue] (h4) [bend right] to (1430);

        \node [below=0.1cm of 1143] (h5) {\textcolor{blue}{HBlank}};
        \draw [thick, blue] (1431) [bend left] to (h5);
        \draw [-stealth, thick, blue] (h5) [bend right] to (1440);

        \path (1441) -- node[pos=0.47] (v) {\textcolor{red}{\bf VBlank}} (00);

        \draw [ultra thick, red] (1441) [bend right] to (v);
        \draw [-stealth, red, ultra thick] (v) [bend left] to (00);

\end{tikzpicture}
```

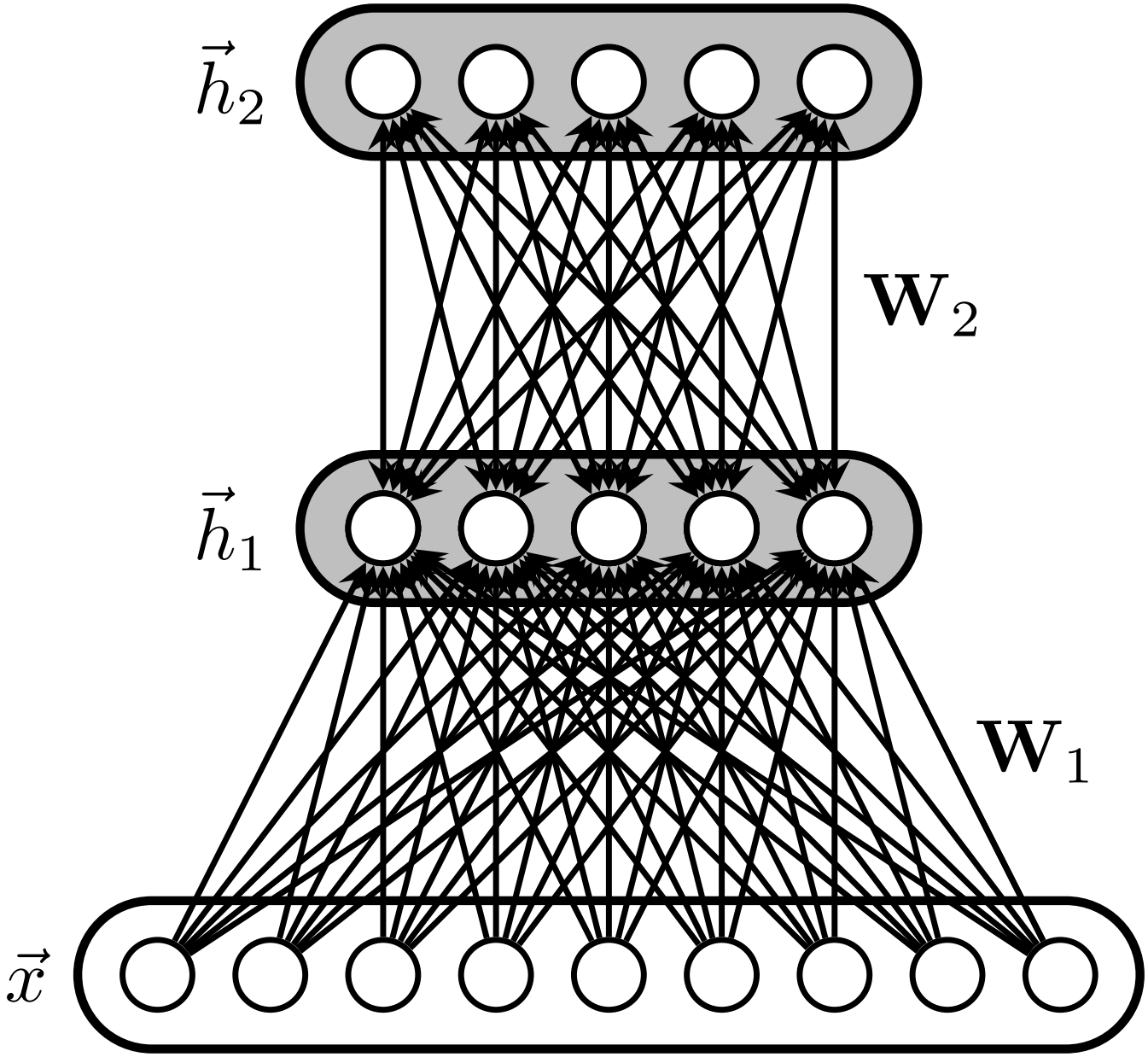
1.12 Cyclegan




```
\begin{tikzpicture}
        \node[circle, draw, thick] (z) {$\vec{a}_{real}$};
        \node[circle, draw, thick, right=5em of z] (x) {$\vec{b}_{fake}$};
        \draw[-stealth, thick] (z) -- node[above] {$G_{AB}(\vec{a})$} node[below, align=center] {generator
            \\ ($A\rightarrow B$)} (x);
        \node[circle, draw, thick, right=5em of x] (xx) {$\vec{a}_{rec}$};
        \draw[-stealth, thick] (x) -- node[above] {$G_{BA}(\vec{b})$} node[below, align=center] {generator
            \\ ($B\rightarrow A$)} (xx);
        \node[left=5em of z] (i) {};
        \draw[-stealth, thick] (i) -- node[above] {real data} node[below] {(type A)} (z);
```

```
        \node[circle, draw, thick, right=2em of x, yshift=7.5em] (D) {$\vec{b}$};
        \node[right=7em of D] (out) {real?};
        \draw[-stealth, thick] (D) -- node[above] {$D_B(\vec{b})$} node[below,align=center] {discriminator
            \\ (type B)} (out);

        \node[yshift=5em, circle, fill, inner sep=0.15em] at (x) (pt1) {};
        \node[above=of x, yshift=6.4em, circle, fill, inner sep=0.15em] (pt2) {};

        \node[left=2.5em of pt2, circle, draw, thick] (xt) {$\vec{b}_{real}$};
        \node[left=5em of xt] (it) {};
        \draw[-stealth, thick] (it) -- node[above] {real data} node[below] {(type B)} (xt);

        \draw[dashed, thick] (pt1) edge[bend left] (pt2);

        \node[circle, draw, thick, fill=white, inner sep=0.15em] at ([xshift=-0.83em, yshift=4em]pt1.north)
             (pt3) {};

        \draw[-stealth, thick] (x) -- (pt1);
        \draw[-stealth, thick] (xt) -- (pt2);
        \draw[-stealth, thick] (pt3) -- (D);

        \draw[dashed, thick, stealth-stealth] (z.south) -- ([yshift=-1.5em]z.south) -- ([yshift=-1.6em]xx.
            south) -- (xx.south);
\end{tikzpicture}
```

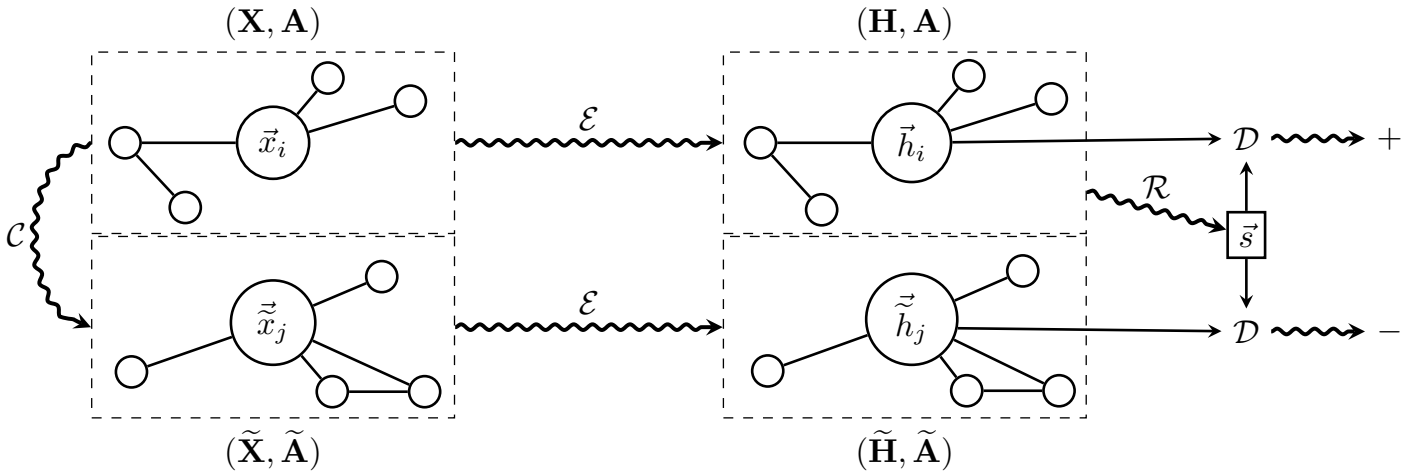
1.13 Deep Belif Network




```
\begin{tikzpicture}

        \node (1) [draw, minimum width=15em, minimum height=2em, very thick, rounded rectangle] {};
        \node (l1) [left=0em of 1] {$\vec{x}$};

        \node (2) [above=3.9em of 1, draw, fill=lightgray, minimum width=9em,very thick, minimum height=2em
            , rounded rectangle] {};
        \node (l2) [left=0em of 2] {$\vec{h}_1$};
        \node (3) [above=3.9em of 2, draw, fill=lightgray, minimum width=9em,very thick, minimum height=2em
            , rounded rectangle] {};
        \node (l3) [left=0em of 3] {$\vec{h}_2$};

        \node[circle, draw, thick] (A1) {};
        \node[circle, draw, thick, right=0.5em of A1] (A2) {};
        \node[circle, draw, thick, right=0.5em of A2] (A3) {};
        \node[circle, draw, thick, right=0.5em of A3] (A4) {};
        \node[circle, draw, thick, right=0.5em of A4] (A5) {};
        \node[circle, draw, thick, left=0.5em of A1] (A6) {};
        \node[circle, draw, thick, left=0.5em of A6] (A7) {};
        \node[circle, draw, thick, left=0.5em of A7] (A8) {};
        \node[circle, draw, thick, left=0.5em of A8] (A9) {};

        \node[circle, draw, fill=white, thick, above=5em of A1] (B1) {};
        \node[circle, draw, fill=white, thick, right=0.5em of B1] (B2) {};
        \node[circle, draw, fill=white, thick, right=0.5em of B2] (B3) {};
```

```
        \node[circle, draw, fill=white, thick, left=0.5em of B1] (B4) {};
        \node[circle, draw, fill=white, thick, left=0.5em of B4] (B5) {};

        \node[circle, draw, fill=white, thick, above=5em of A1] (B1) {};
        \node[circle, draw, fill=white, thick, right=0.5em of B1] (B2) {};
        \node[circle, draw, fill=white, thick, right=0.5em of B2] (B3) {};
        \node[circle, draw, fill=white, thick, left=0.5em of B1] (B4) {};
        \node[circle, draw, fill=white, thick, left=0.5em of B4] (B5) {};

        \node[circle, draw, fill=white, thick, above=5em of A1] (B1) {};
        \node[circle, draw, fill=white, thick, right=0.5em of B1] (B2) {};
        \node[circle, draw, fill=white, thick, right=0.5em of B2] (B3) {};
        \node[circle, draw, fill=white, thick, left=0.5em of B1] (B4) {};
        \node[circle, draw, fill=white, thick, left=0.5em of B4] (B5) {};

        \node[circle, draw, fill=white, thick, above=5em of B1] (C1) {};
        \node[circle, draw, fill=white, thick, right=0.5em of C1] (C2) {};
        \node[circle, draw, fill=white, thick, right=0.5em of C2] (C3) {};
        \node[circle, draw, fill=white, thick, left=0.5em of C1] (C4) {};
        \node[circle, draw, fill=white, thick, left=0.5em of C4] (C5) {};

        \foreach \x in {1,...,9}
                \foreach \y in {1,...,5}
                        \draw[-stealth, thick] (A\x) -- (B\y);

        \foreach \x in {1,...,5}
                \foreach \y in {1,...,5}
                        \draw[stealth-stealth, thick] (B\x) -- (C\y);

        \draw[-stealth, thick] (A5) -- node[right] {${\bf W}_1$} (B3);
        \draw[stealth-stealth, thick] (B3) -- node[right] {${\bf W}_2$} (C3);

\end{tikzpicture}
```

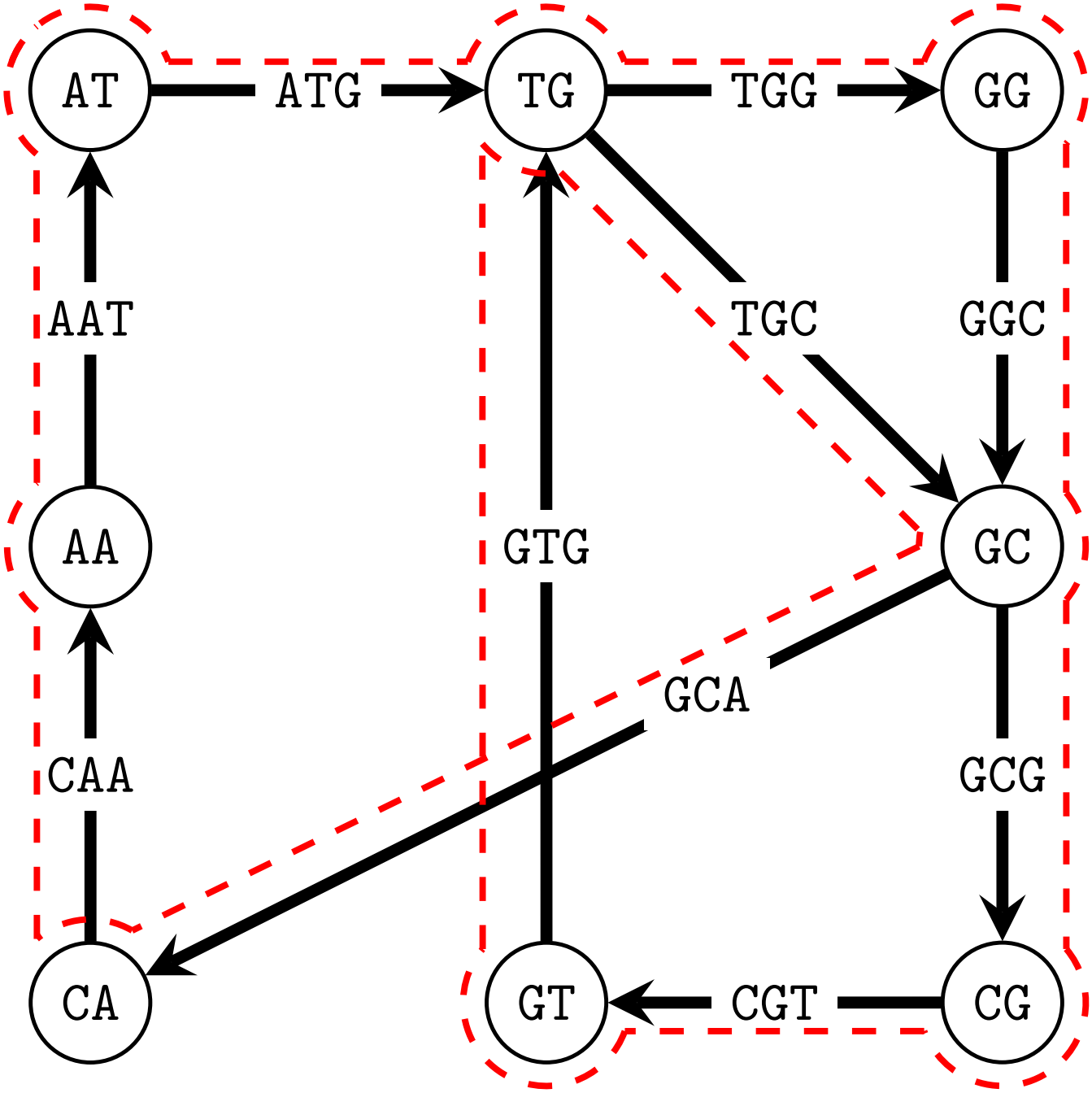
1.14 Deep Graph Infomax




```
\begin{tikzpicture}
        \node[circle, thick, draw] (0) {$\vec{x}_i$};
        \node[circle, thick, draw, above right=0.1em and 3em of 0] (1) {};
        \node[circle, thick, draw, above right=0.8em and 0.5em of 0] (2) {};
        \node[circle, thick, draw, left=of 0] (3) {};
        \node[circle, thick, draw, below left=0.8em and 1.5em of 0] (4) {};

        \draw[-, thick] (0) -- (1);
        \draw[-, thick] (0) -- (2);
        \draw[-, thick] (0) -- (3);
        \draw[-, thick] (4) -- (3);

        \node[circle, thick, draw, below=3em of 0] (01) {$\vec{\widetilde{x}}_j$};
        \node[circle, thick, draw, above right=0.1em and 2em of 01] (02) {};
        \node[circle, thick, draw, below left=0.2em and 3em of 01] (03) {};
        \node[circle, thick, draw, below right=0.8em and 0.5em of 01] (04) {};
        \node[circle, thick, draw, below right=0.8em and 3.3em of 01] (05) {};
```

```
        \node[rectangle, draw, dashed, minimum width=11em, minimum height=5.5em] (RR) {};
        \node[rectangle, draw, dashed, minimum width=11em, minimum height=5.5em, below=0.05em of RR] (RR2)
            {};
        \node[above=0em of RR] (11) {$({\bf X}, {\bf A})$};
        \node[below=0em of RR2] (12) {$({\bf \widetilde{X}}, {\bf \widetilde{A}})$};

        \draw[-, thick] (01) -- (02);
        \draw[-, thick] (01) -- (03);
        \draw[-, thick] (01) -- (04);
        \draw[-, thick] (01) -- (05);
        \draw[-, thick] (04) -- (05);

        \node[rectangle, draw, dashed, minimum width=11em, minimum height=5.5em, right=12.5em of 0] (AA)
            {};

        \node[circle, thick, draw, right=17em of 0] (0) {$\vec{h}_i$};
        \node[circle, thick, draw, above right=0.1em and 3em of 0] (1) {};
        \node[circle, thick, draw, above right= 0.8em and 0.5em of 0] (2) {};
        \node[circle, thick, draw, left=of 0] (3) {};
        \node[circle, thick, draw, below left=0.8em and 1.5em of 0] (4) {};

        \draw[-, thick] (0) -- (1);
        \draw[-, thick] (0) -- (2);
        \draw[-, thick] (0) -- (3);
        \draw[-, thick] (4) -- (3);

        \node[circle, thick, draw, below=2.7em of 0] (01) {$\vec{\widetilde{h}}_j$};
        \node[circle, thick, draw, above right=0.1em and 2emof 01] (02) {};
        \node[circle, thick, draw, below left=0.2em and 3em of 01] (03) {};
        \node[circle, thick, draw, below right=0.8em and 0.3em of 01] (04) {};
        \node[circle, thick, draw, below right=0.8em and 3.1em of 01] (05) {};
        \node[rectangle, draw, minimum width=11em, minimum height=5.5em, dashed, below=0.05em of AA] (AA2)
            {};
        \node[above=0em of AA] (11) {$({\bf H}, {\bf A})$};
        \node[below=0em of AA2] (12) {$({\bf \widetilde{H}}, {\bf \widetilde{A}})$};

        \draw[-, thick] (01) -- (02);
        \draw[-, thick] (01) -- (03);
        \draw[-, thick] (01) -- (04);
        \draw[-, thick] (01) -- (05);
        \draw[-, thick] (04) -- (05);

        \draw[-stealth, very thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate,] (RR) -- node[above] {$\mathcal{E}$} (AA);
        \draw[very thick] (RR.west) edge[bend right=75, decoration={snake, pre length=0.01mm, segment
            length=2mm, amplitude=0.3mm, post length=1.5mm}, decorate,-stealth] node[left] (CC) {$\mathcal{
            C}$} (RR2.west);
        \draw[-stealth, very thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate,] (RR2) -- node[above] {$\mathcal{E}$} (AA2);

        \node[right=36em of CC, rectangle, draw, thick] (Re) {$\vec{s}$};

        \draw[-stealth, very thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate,] (AA) -- node[above] {$\mathcal{R}$} (Re);

        \node[above=1.5em of Re] (D1) {$\mathcal{D}$};
        \node[below=1.5em of Re] (D2) {$\mathcal{D}$};

        \draw[-stealth, thick] (Re) -- (D1);
        \draw[-stealth, thick] (Re) -- (D2);
        \draw[-stealth, thick] (0) -- (D1);
        \draw[-stealth, thick] (01.-11) -- (D2);

        \node[right=of D1] (P) {$+$};
        \node[right=of D2] (M) {$-$};

        \draw[-stealth, very thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate,] (D1) -- (P);
        \draw[-stealth, very thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate,] (D2) -- (M);

\end{tikzpicture}
```

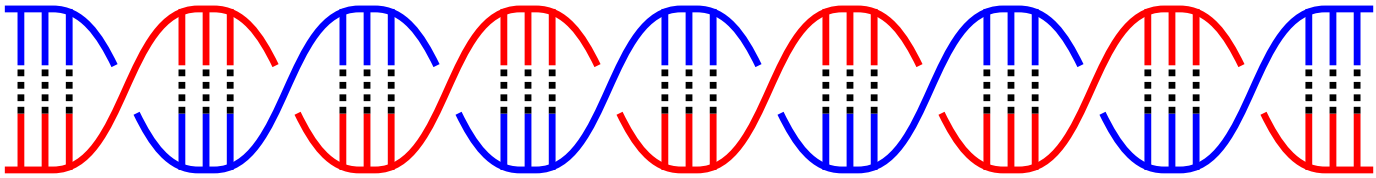
1.15 de-bruijn-graph




```
\begin{tikzpicture}[scale=0.8,every node/.style={scale=0.7},font=\tt]
        \SetUpEdge[lw         = 1.5pt,
                               color      = black,
                               labelcolor = white]
        \GraphInit[vstyle=Normal]
        \SetGraphUnit{2.5}
        \tikzset{VertexStyle/.append  style={fill}}
        \Vertex{AT}
        \EA(AT){TG}
        \EA(TG){GG}
        \SO(GG){GC}
        \SO(GC){CG}
        \WE(CG){GT}
        \WE(GT){CA}
        \NO(CA){AA}
        \tikzset{EdgeStyle/.style={-stealth}}
        \Edge[label=ATG](AT)(TG)
        \Edge[label=TGG](TG)(GG)
```

```
        \Edge[label=GGC](GG)(GC)
        \Edge[label=GCG](GC)(CG)
        \Edge[label=CGT](CG)(GT)
        \Edge[label=GTG](GT)(TG)
        \Edge[label=TGC](TG)(GC)
        \Edge[label=GCA, style={pos=.3}](GC)(CA)
        \Edge[label=CAA](CA)(AA)
        \Edge[label=AAT](AA)(AT)

        \draw[thick, red, dashed] (AT) ++(160:13pt)coordinate(AT1)  arc (-200:-340:13pt)   coordinate(AT2);
        \draw[thick, red, dashed] (TG) ++(160:13pt)coordinate(TG1)  arc (-200:-340:13pt)   coordinate(TG2);
        \draw[thick, red, dashed] (GG) ++(160:13pt)coordinate(GG1)  arc (-200:-400:13pt)   coordinate(GG2);
        \draw[thick, red, dashed] (GC) ++(40:13pt)coordinate(GC1)  arc (-320:-400:13pt)   coordinate(GC2);
        \draw[thick, red, dashed] (CG) ++(40:13pt)coordinate(CG1)  arc (-320:-520:13pt)   coordinate(CG2);
        \draw[thick, red, dashed] (GT) ++(-20:13pt)coordinate(GT1)  arc (-380:-580:13pt)   coordinate(GT2);
        \draw[thick, red, dashed] (TG) ++(-140:13pt)coordinate(TG11)  arc (-500:-440:13pt)   coordinate(TG
            12);
        \draw[thick, red, dashed] (GC) ++(-550:13pt)coordinate(GC11)  arc (-550:-540:13pt)   coordinate(GC
            12);
        \draw[thick, red, dashed] (CA) ++(-660:13pt)coordinate(CA1)  arc (-660:-590:13pt)   coordinate(CA2)
            ;
        \draw[thick, red, dashed] (AA) ++(-490:13pt)coordinate(AA1)  arc (-490:-590:13pt)   coordinate(AA2)
            ;
        \draw[thick, red, dashed] (AT) ++(-490:13pt)coordinate(AT11)  arc (-490:-590:13pt)   coordinate(AT
            12);

        \draw[thick, red, dashed, rounded corners=3mm] (AT2) --(TG1);
        \draw[thick, red, dashed, rounded corners=3mm] (TG2) --(GG1);
        \draw[thick, red, dashed, rounded corners=3mm] (GG2) --(GC1);
        \draw[thick, red, dashed, rounded corners=3mm] (GC2) --(CG1);
        \draw[thick, red, dashed, rounded corners=3mm] (CG2) --(GT1);
        \draw[thick, red, dashed, rounded corners=3mm] (GT2) --(TG11);
        \draw[thick, red, dashed, rounded corners=3mm] (TG12) --(GC11);
        \draw[thick, red, dashed, rounded corners=3mm] (GC12) --(CA1);
        \draw[thick, red, dashed, rounded corners=3mm] (CA2) --(AA1);
        \draw[thick, red, dashed, rounded corners=3mm] (AA2) --(AT11);
\end{tikzpicture}
```

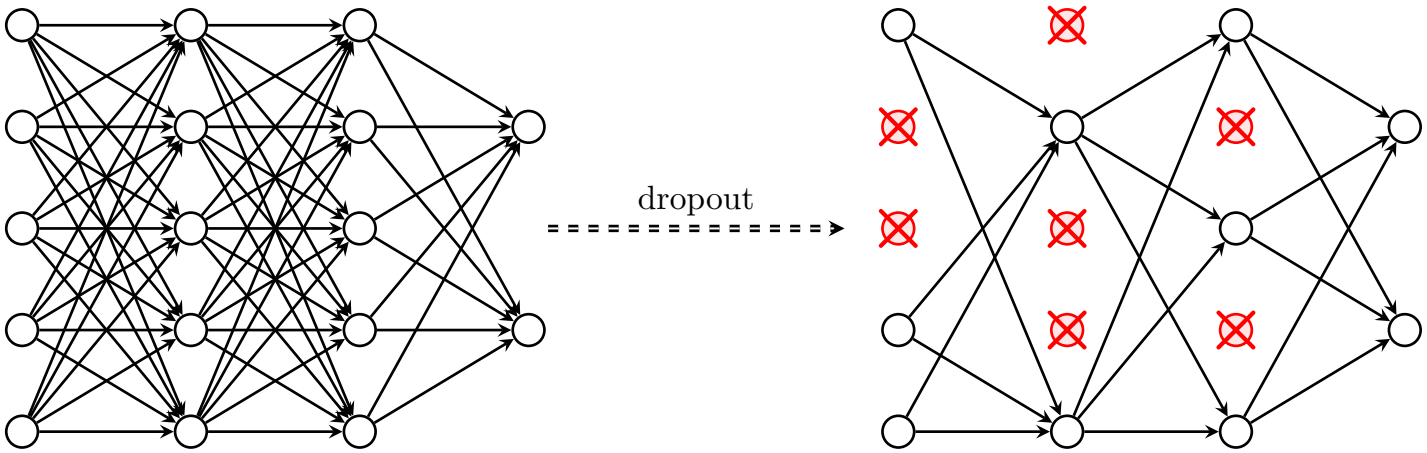
1.16 DNA



```
\newcommand{\bond}[3]{
\draw[very thick, #1] (#3, 0) -- (#3, 0.35);
\draw[very thick, densely dotted] (#3, 0.35) -- (#3, 0.65);
\draw[very thick, #2] (#3, 0.65) -- (#3, 1);
}

\begin{tikzpicture}
        \bond{red}{blue}{0.1}
        \bond{red}{blue}{0.25}
        \bond{red}{blue}{0.4}
        \bond{blue}{red}{1.1}
        \bond{blue}{red}{1.25}
        \bond{blue}{red}{1.4}
        \bond{red}{blue}{2.1}
        \bond{red}{blue}{2.25}
        \bond{red}{blue}{2.4}
        \bond{blue}{red}{3.1}
        \bond{blue}{red}{3.25}
        \bond{blue}{red}{3.4}
        \bond{red}{blue}{4.1}
        \bond{red}{blue}{4.25}
        \bond{red}{blue}{4.4}
        \bond{blue}{red}{5.1}
        \bond{blue}{red}{5.25}
        \bond{blue}{red}{5.4}
        \bond{red}{blue}{6.1}
        \bond{red}{blue}{6.25}
```

```
        \bond{red}{blue}{6.4}
        \bond{blue}{red}{7.1}
        \bond{blue}{red}{7.25}
        \bond{blue}{red}{7.4}
        \bond{red}{blue}{8.1}
        \bond{red}{blue}{8.25}
        \bond{red}{blue}{8.4}
        \braid[rotate=90,style strands={1}{red, very thick},style strands={2}{blue, very thick}] (tst) at
            (0, 0) s_1 s_1 s_1 s_1 s_1 s_1 s_1 s_1;
\end{tikzpicture}
```

1.17 Dropout

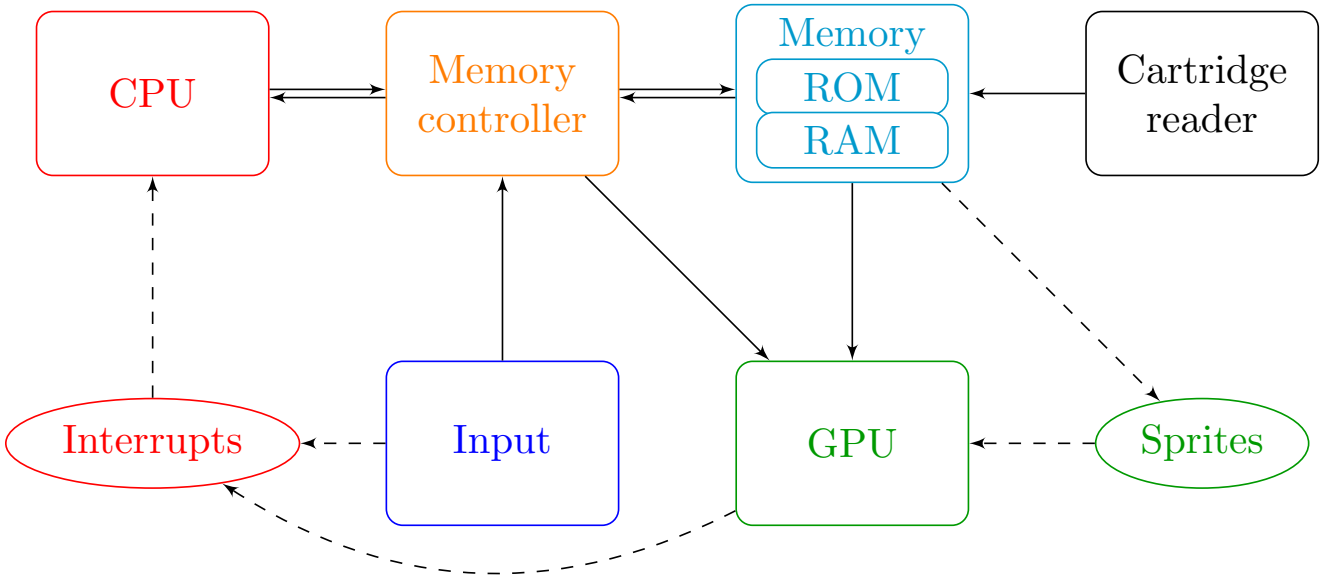



```
\begin{tikzpicture}

        \node[circle, draw, thick] (i1) {};
        \node[circle, draw, thick, above=2em of i1] (i2) {};
        \node[circle, draw, thick, above=2em of i2] (i3) {};
        \node[circle, draw, thick, below=2em of i1] (i4) {};
        \node[circle, draw, thick, below=2em of i4] (i5) {};

        \node[circle, draw, thick, right=4em of i1] (h1) {};
        \node[circle, draw, thick, right=4em of i2] (h2) {};
        \node[circle, draw, thick, right=4em of i3] (h3) {};
        \node[circle, draw, thick, right=4em of i4] (h4) {};
        \node[circle, draw, thick, right=4em of i5] (h5) {};

        \node[circle, draw, thick, right=4em of h1] (hh1) {};
        \node[circle, draw, thick, right=4em of h2] (hh2) {};
        \node[circle, draw, thick, right=4em of h3] (hh3) {};
        \node[circle, draw, thick, right=4em of h4] (hh4) {};
        \node[circle, draw, thick, right=4em of h5] (hh5) {};

        \node[circle, draw, thick, right=4em of hh2] (o1) {};
        \node[circle, draw, thick, right=4em of hh4] (o2) {};

        \draw[-stealth, thick] (i1) -- (h1);
        \draw[-stealth, thick] (i1) -- (h2);
        \draw[-stealth, thick] (i1) -- (h3);
        \draw[-stealth, thick] (i1) -- (h4);
        \draw[-stealth, thick] (i1) -- (h5);
        \draw[-stealth, thick] (i2) -- (h1);
        \draw[-stealth, thick] (i2) -- (h2);
        \draw[-stealth, thick] (i2) -- (h3);
        \draw[-stealth, thick] (i2) -- (h4);
        \draw[-stealth, thick] (i2) -- (h5);
        \draw[-stealth, thick] (i3) -- (h1);
        \draw[-stealth, thick] (i3) -- (h2);
        \draw[-stealth, thick] (i3) -- (h3);
        \draw[-stealth, thick] (i3) -- (h4);
        \draw[-stealth, thick] (i3) -- (h5);
        \draw[-stealth, thick] (i4) -- (h1);
        \draw[-stealth, thick] (i4) -- (h2);
        \draw[-stealth, thick] (i4) -- (h3);
        \draw[-stealth, thick] (i4) -- (h4);
```

```
\draw[-stealth, thick] (i4) -- (h5);
\draw[-stealth, thick] (i5) -- (h1);
\draw[-stealth, thick] (i5) -- (h2);
\draw[-stealth, thick] (i5) -- (h3);
\draw[-stealth, thick] (i5) -- (h4);
\draw[-stealth, thick] (i5) -- (h5);

\draw[-stealth, thick] (h1) -- (hh1);
\draw[-stealth, thick] (h1) -- (hh2);
\draw[-stealth, thick] (h1) -- (hh3);
\draw[-stealth, thick] (h1) -- (hh4);
\draw[-stealth, thick] (h1) -- (hh5);
\draw[-stealth, thick] (h2) -- (hh1);
\draw[-stealth, thick] (h2) -- (hh2);
\draw[-stealth, thick] (h2) -- (hh3);
\draw[-stealth, thick] (h2) -- (hh4);
\draw[-stealth, thick] (h2) -- (hh5);
\draw[-stealth, thick] (h3) -- (hh1);
\draw[-stealth, thick] (h3) -- (hh2);
\draw[-stealth, thick] (h3) -- (hh3);
\draw[-stealth, thick] (h3) -- (hh4);
\draw[-stealth, thick] (h3) -- (hh5);
\draw[-stealth, thick] (h4) -- (hh1);
\draw[-stealth, thick] (h4) -- (hh2);
\draw[-stealth, thick] (h4) -- (hh3);
\draw[-stealth, thick] (h4) -- (hh4);
\draw[-stealth, thick] (h4) -- (hh5);
\draw[-stealth, thick] (h5) -- (hh1);
\draw[-stealth, thick] (h5) -- (hh2);
\draw[-stealth, thick] (h5) -- (hh3);
\draw[-stealth, thick] (h5) -- (hh4);
\draw[-stealth, thick] (h5) -- (hh5);


\draw[-stealth, thick] (hh1) -- (o1);
\draw[-stealth, thick] (hh1) -- (o2);
\draw[-stealth, thick] (hh2) -- (o1);
\draw[-stealth, thick] (hh2) -- (o2);
\draw[-stealth, thick] (hh3) -- (o1);
\draw[-stealth, thick] (hh3) -- (o2);
\draw[-stealth, thick] (hh4) -- (o1);
\draw[-stealth, thick] (hh4) -- (o2);
\draw[-stealth, thick] (hh5) -- (o1);
\draw[-stealth, thick] (hh5) -- (o2);

\draw[-stealth, double, dashed, thick] (5.5,0) -- node[above] {dropout} (8.6, 0);


%%% BOUNDARY %%%

\node[circle, draw, thick, red, fill=red!10, right=15em of hh1] (i1) {};
\node[circle, draw, thick, red, fill=red!10, above=2em of i1] (i2) {};
\node[circle, draw, thick, above=2em of i2] (i3) {};
\node[circle, draw, thick, below=2em of i1] (i4) {};
\node[circle, draw, thick, below=2em of i4] (i5) {};

\node[red] (icr) at (i1) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
    }}}}}}$};
\node[red] (icr) at (i2) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
    }}}}}}$};

\node[circle, draw, thick, red, fill=red!10, right=4em of i1] (h1) {};
\node[circle, draw, thick, right=4em of i2] (h2) {};
\node[circle, draw, thick, red, fill=red!10, right=4em of i3] (h3) {};
\node[circle, draw, thick, red, fill=red!10, right=4em of i4] (h4) {};
\node[circle, draw, thick, right=4em of i5] (h5) {};

\node[red] (icr) at (h1) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
    }}}}}}$};
\node[red] (icr) at (h3) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
    }}}}}}$};
\node[red] (icr) at (h4) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
    }}}}}}$};

\node[circle, draw, thick, right=4em of h1] (hh1) {};
\node[circle, draw, thick, red, fill=red!10, right=4em of h2] (hh2) {};
```

```
        \node[circle, draw, thick, right=4em of h3] (hh3) {};
        \node[circle, draw, thick, red, fill=red!10, right=4em of h4] (hh4) {};
        \node[circle, draw, thick, right=4em of h5] (hh5) {};

        \node[red] (icr) at (hh2) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
            }}}}}}$};
        \node[red] (icr) at (hh4) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
            }}}}}}$};

        \node[circle, draw, thick, right=4em of hh2] (o1) {};
        \node[circle, draw, thick, right=4em of hh4] (o2) {};

        \draw[-stealth, thick] (i3) -- (h2);
        \draw[-stealth, thick] (i3) -- (h5);
        \draw[-stealth, thick] (i4) -- (h2);
        \draw[-stealth, thick] (i4) -- (h5);
        \draw[-stealth, thick] (i5) -- (h2);
        \draw[-stealth, thick] (i5) -- (h5);

        \draw[-stealth, thick] (h2) -- (hh1);
        \draw[-stealth, thick] (h2) -- (hh3);
        \draw[-stealth, thick] (h2) -- (hh5);
        \draw[-stealth, thick] (h5) -- (hh1);
        \draw[-stealth, thick] (h5) -- (hh3);
        \draw[-stealth, thick] (h5) -- (hh5);

        \draw[-stealth, thick] (hh1) -- (o1);
        \draw[-stealth, thick] (hh1) -- (o2);
        \draw[-stealth, thick] (hh3) -- (o1);
        \draw[-stealth, thick] (hh3) -- (o2);
        \draw[-stealth, thick] (hh5) -- (o1);
        \draw[-stealth, thick] (hh5) -- (o2);

\end{tikzpicture}
```

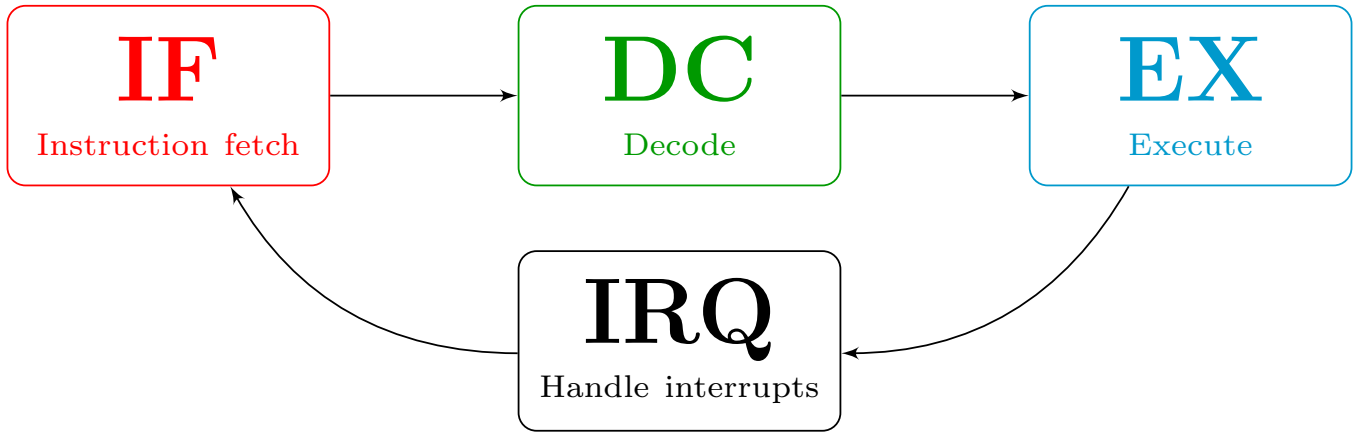
1.18 Emulator Modules




```
\tikzstyle{block} = [rectangle, draw, fill=blue!20,
    text width=5em, text centered, rounded corners, minimum height=4em]
\tikzstyle{block2} = [rectangle, draw, fill=blue!20,
    text width=4em, text centered, rounded corners, minimum height=1em]
\tikzstyle{cloud} = [draw, ellipse,fill=red!20, node distance=3cm,
    minimum height=2em]
\tikzstyle{line} = [draw, -latex']

\definecolor{mygreen}{rgb}{0,0.6,0}
\definecolor{echodrk}{HTML}{0099cc}
\definecolor{drkorange}{HTML}{FF7c00}

\begin{tikzpicture}[node distance=3cm, auto]
```

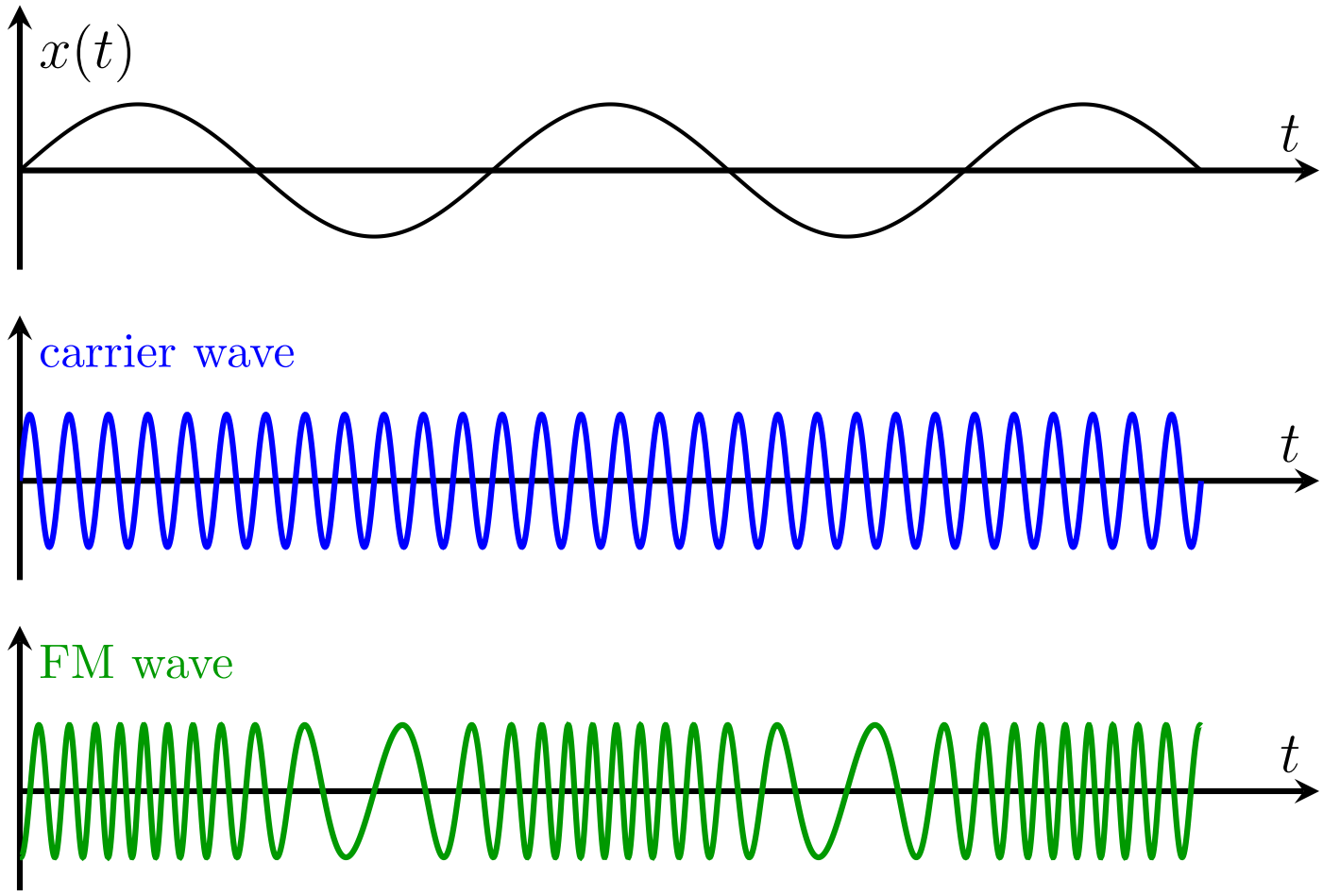
```
        \node [block, color=red, fill=white] (cpu) {CPU};
        \node [cloud, color=red, fill=white, below of=cpu] (intr) {Interrupts};
        \node [block, color=drkorange, fill=white, right of=cpu] (mmu) {Memory controller};
        \node [block, color=echodrk, fill=white, right of=mmu] (memo) {Memory \begin{tikzpicture}\node [
            block2, color=echodrk, fill=white] (rom) {ROM};\node [block2, node distance=1.3em, below of=rom
            , color=echodrk, fill=white] (ram) {RAM};\end{tikzpicture}};
        \node [block, color=black, fill=white, right of=memo] (cartr) {Cartridge reader};
        \node [block, color=mygreen, fill=white, below of=memo] (gpu) {GPU};
        \node [cloud, color=mygreen, fill=white, right of=gpu] (sprites) {Sprites};
        \node [block, color=blue, fill=white, left of=gpu] (io) {Input};

        \path [line,transform canvas={yshift=0.1em}] (cpu) -- (mmu);
        \path [line,transform canvas={yshift=-0.1em}] (mmu) -- (cpu);
        \path [line,transform canvas={yshift=0.1em}] (mmu) -- (memo);
        \path [line,transform canvas={yshift=-0.1em}] (memo) -- (mmu);
        \path [line] (io) -- (mmu);
        \path [line] (mmu) -- (gpu);
        \path [line] (memo) -- (gpu);
        \path [line, dashed] (intr) -- (cpu);
        \path [line, dashed] (io) -- (intr);
        \path [line, dashed] (gpu) edge [bend left] (intr);
        \path [line] (cartr) -- (memo);
        \path [line, dashed] (memo) -- (sprites);
        \path [line, dashed] (sprites) -- (gpu);
\end{tikzpicture}
```

1.19 Fetch Decode Execute cycle




```
\tikzstyle{block} = [rectangle, draw, fill=blue!20,
    text width=5em, text centered, rounded corners, minimum height=4em]
\tikzstyle{line} = [draw, -latex']

\definecolor{mygreen}{rgb}{0,0.6,0}
\definecolor{echodrk}{HTML}{0099cc}

\begin{tikzpicture}[node distance=4cm, auto]
        \node [block, color=red, fill=white, text width=6.5em] (if) {{\huge \bf IF}\\{\scriptsize
            Instruction fetch}};
        \node [block, color=mygreen, fill=white, text width=6.5em, right of=if] (dc) {{\huge \bf DC}\\{\
            scriptsize Decode}};
        \node [block, color=echodrk, fill=white, text width=6.5em, right of=dc] (ex) {{\huge \bf EX}\\{\
            scriptsize Execute}};
        \node [block, color=black, fill=white, text width=6.5em, below = 0.5cm of dc] (intr) {{\huge \bf
            IRQ}\\{\scriptsize Handle interrupts}};

        \path [line] (if) -- (dc);
        \path [line] (dc) -- (ex);
        \path [line] (ex) edge [bend left] (intr);
        \path [line] (intr) edge [bend left] (if);
\end{tikzpicture}
```

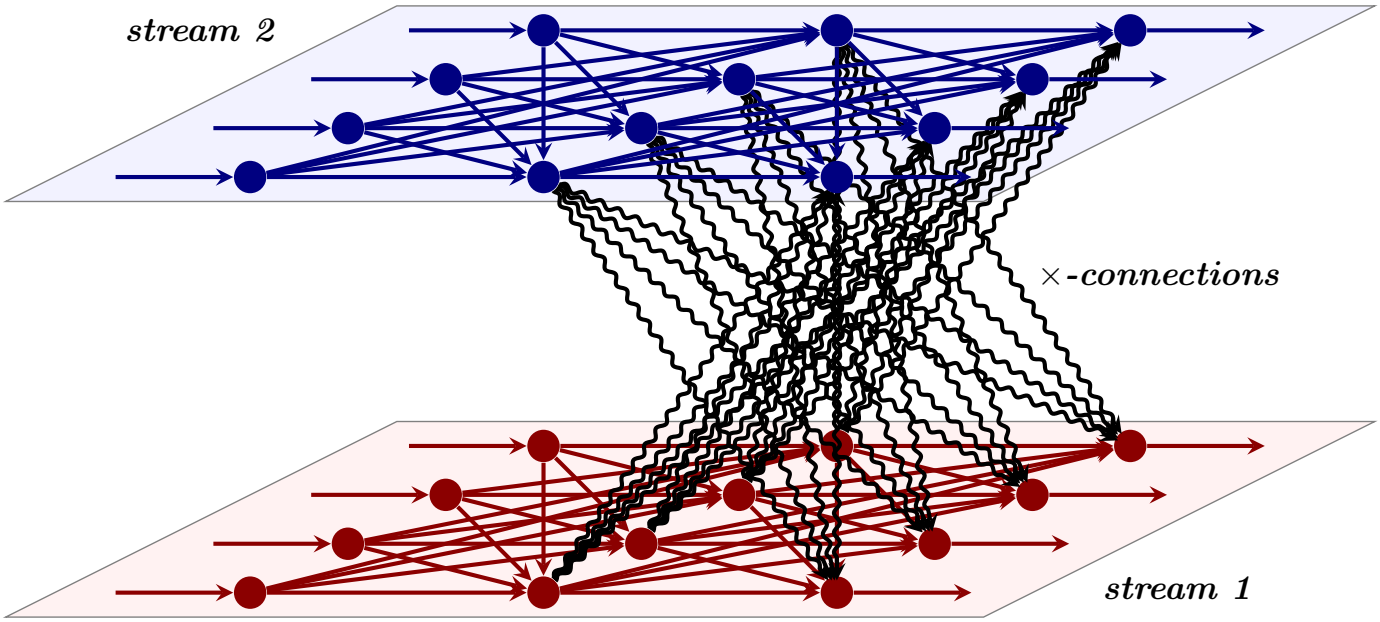
1.20 Frequence Modulation




```
\definecolor{olivegreen}{rgb}{0,0.6,0}

\begin{tikzpicture}[samples=1000, domain=0:10]

        \begin{axis}[
                width=11cm, height=3.5cm,
                xtick=\empty,
                ytick=\empty,
                xlabel={\large $t$},
                ylabel={\large $x(t)$},
                xmin=0, xmax=11,
                ymin=-3, ymax=5,
                axis lines = middle,
                very thick,
                trig format = rad
        ]
                \addplot [no markers, smooth, thick] {2*sin(2*pi*0.25*x)};
        \end{axis}

        \begin{axis}[
                at={(0, -2.25cm)},
                width=11cm, height=3.5cm,
                xtick=\empty,
                ytick=\empty,
                xlabel={\large $t$},
                ylabel={\textcolor{blue}{carrier wave}},
                xmin=0, xmax=11,
                ymin=-3, ymax=5,
                axis lines = middle,
                very thick,
                trig format = rad
        ]
                \addplot [no markers, smooth, blue, very thick] {2*sin(6*pi*x)};
        \end{axis}
```

```
        \begin{axis}[
                at={(0, -4.5cm)},
                width=11cm, height=3.5cm,
                xtick=\empty,
                ytick=\empty,
                xlabel={\large $t$},
                ylabel={\textcolor{olivegreen}{FM wave}},
                xmin=0, xmax=11,
                ymin=-3, ymax=5,
                axis lines = middle,
                very thick,
                trig format = rad
        ]
                \addplot expression [no markers, smooth, olivegreen, very thick] {2*sin(2*pi*3*x - 8*cos(2*
                    pi*0.25*x))};
        \end{axis}

\end{tikzpicture}
```

1.21 Fully Connected Cross Connection

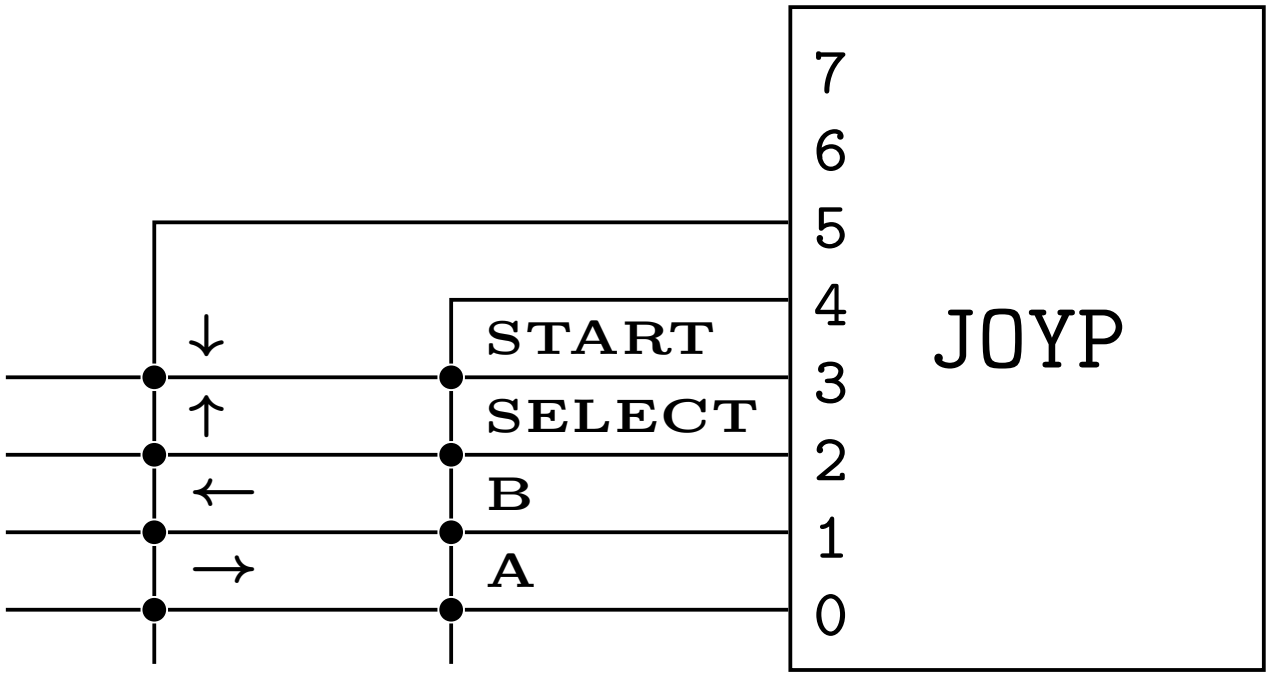



```
\definecolor{mynavy}{HTML}{000080}
\definecolor{darkred}{HTML}{8B0000}

\newcommand{\myGlobalTransformation}[2]
{
    \pgftransformcm{1}{0}{0.5}{0.25}{\pgfpoint{#1cm}{#2cm}}
}

\tikzstyle myBG=[line width=3pt,opacity=1.0]

\begin{tikzpicture}

        \begin{scope}
                \myGlobalTransformation{0}{0};
                \draw [black!50,fill=red!5] (-1, 0) rectangle (9,8);
        \end{scope}

        \begin{scope}
                \myGlobalTransformation{0}{4.25};
                \draw [black!50,fill=blue!5] (-1, 0) rectangle (9,8);
        \end{scope}

        \begin{scope}
                \myGlobalTransformation{0}{0}
                \node (N1) at (1,1) [circle,white,fill=darkred] {};
                \node (N2) at (1,3) [circle,white,fill=darkred] {};
                \node (N3) at (1,5) [circle,white,fill=darkred] {};
```

```
            \node (N4) at (1,7) [circle,white,fill=darkred] {};
            \node (N5) at (4,1) [circle,white,fill=darkred] {};
            \node (N6) at (4,3) [circle,white,fill=darkred] {};
            \node (N7) at (4,5) [circle,white,fill=darkred] {};
            \node (N8) at (4,7) [circle,white,fill=darkred] {};
            \node (N9) at (7,1) [circle,white,fill=darkred] {};
            \node (N10) at (7,3) [circle,white,fill=darkred] {};
            \node (N11) at (7,5) [circle,white,fill=darkred] {};
            \node (N12) at (7,7) [circle,white,fill=darkred] {};

            \node (N13) at (8.5,1) {};
            \node (N14) at (8.5,3) {};
            \node (N15) at (8.5,5) {};
            \node (N16) at (8.5,7) {};

            \node (N0) at (-0.5,1) {};
            \node (N00) at (-0.5,3) {};
            \node (N000) at (-0.5,5) {};
            \node (N0000) at (-0.5,7) {};

            \foreach \x in {1,...,4}
                    \foreach \y in {5,...,8}
                    \draw[-stealth, darkred, very thick] (N\x) -- (N\y);

            \foreach \x in {5,...,8}
                    \foreach \y in {9,...,12}
                    \draw[-stealth, darkred, very thick] (N\x) -- (N\y);

    \draw[-stealth, darkred, very thick] (N9) -- (N13);
    \draw[-stealth, darkred, very thick] (N10) -- (N14);
    \draw[-stealth, darkred, very thick] (N11) -- (N15);
    \draw[-stealth, darkred, very thick] (N12) -- (N16);
    \draw[-stealth, darkred, very thick] (N0) -- (N1);
    \draw[-stealth, darkred, very thick] (N00) -- (N2);
    \draw[-stealth, darkred, very thick] (N000) -- (N3);
    \draw[-stealth, darkred, very thick] (N0000) -- (N4);

    \begin{scope}
    \pgftransformreset
            \myGlobalTransformation{0}{4.25};
    \node (T9) at (7,1) {};
    \node (T10) at (7,3) {};
    \node (T11) at (7,5) {};
    \node (T12) at (7,7) {};
    \foreach \x in {5,...,8}
                    \foreach \y in {9,...,12}
                    \draw[-stealth,very thick, decoration={snake, pre length=0.01mm, segment length=2mm
                        , amplitude=0.3mm, post length=1.5mm}, decorate,] (N\x) -- (T\y);
    \end{scope}
    \end{scope}

    \begin{scope}
            \myGlobalTransformation{0}{4.25}
            \node (N1) at (1,1) [circle,white,fill=mynavy] {};
            \node (N2) at (1,3) [circle,white,fill=mynavy] {};
            \node (N3) at (1,5) [circle,white,fill=mynavy] {};
            \node (N4) at (1,7) [circle,white,fill=mynavy] {};
            \node (N5) at (4,1) [circle,white,fill=mynavy] {};
            \node (N6) at (4,3) [circle,white,fill=mynavy] {};
            \node (N7) at (4,5) [circle,white,fill=mynavy] {};
            \node (N8) at (4,7) [circle,white,fill=mynavy] {};

            \node (N13) at (8.5,1) {};
            \node (N14) at (8.5,3) {};
            \node (N15) at (8.5,5) {};
            \node (N16) at (8.5,7) {};
            \node (N0) at (-0.5,1) {};
            \node (N00) at (-0.5,3) {};
            \node (N000) at (-0.5,5) {};
            \node (N0000) at (-0.5,7) {};

            \begin{scope}
    \pgftransformreset
            \myGlobalTransformation{0}{0};
    \node (T9) at (7,1) {};
    \node (T10) at (7,3) {};
```

```
        \node (T11) at (7,5) {};
        \node (T12) at (7,7) {};
        \foreach \x in {5,...,8}
                        \foreach \y in {9,...,12}
                        \draw[-stealth,very thick, decoration={snake, pre length=0.01mm, segment length=2mm
                            , amplitude=0.3mm, post length=1.5mm}, decorate,] (N\x) -- (T\y);
        \end{scope}


                \node (N9) at (7,1) [circle,white,fill=mynavy] {};
                \node (N10) at (7,3) [circle,white,fill=mynavy] {};
                \node (N11) at (7,5) [circle,white,fill=mynavy] {};
                \node (N12) at (7,7) [circle,white,fill=mynavy] {};
        \draw[-stealth, mynavy, very thick] (N0) -- (N1);
        \draw[-stealth, mynavy, very thick] (N00) -- (N2);
        \draw[-stealth, mynavy, very thick] (N000) -- (N3);
        \draw[-stealth, mynavy, very thick] (N0000) -- (N4);

                \foreach \x in {1,...,4}
                        \foreach \y in {5,...,8}
                        \draw[-stealth, mynavy, very thick] (N\x) -- (N\y);

                \foreach \x in {5,...,8}
                        \foreach \y in {9,...,12}
                        \draw[-stealth, mynavy, very thick] (N\x) -- (N\y);

        \draw[-stealth, mynavy, very thick] (N9) -- (N13);
        \draw[-stealth, mynavy, very thick] (N10) -- (N14);
        \draw[-stealth, mynavy, very thick] (N11) -- (N15);
        \draw[-stealth, mynavy, very thick] (N12) -- (N16);

        \end{scope}

        \node at (11, 0.3) {\emph{\textbf{stream 1}}};
        \node at (1, 6) {\emph{\textbf{stream 2}}};

        \node at (10.8, 3.5) {\emph{\textbf{$\times$-connections}}};

\end{tikzpicture}
```

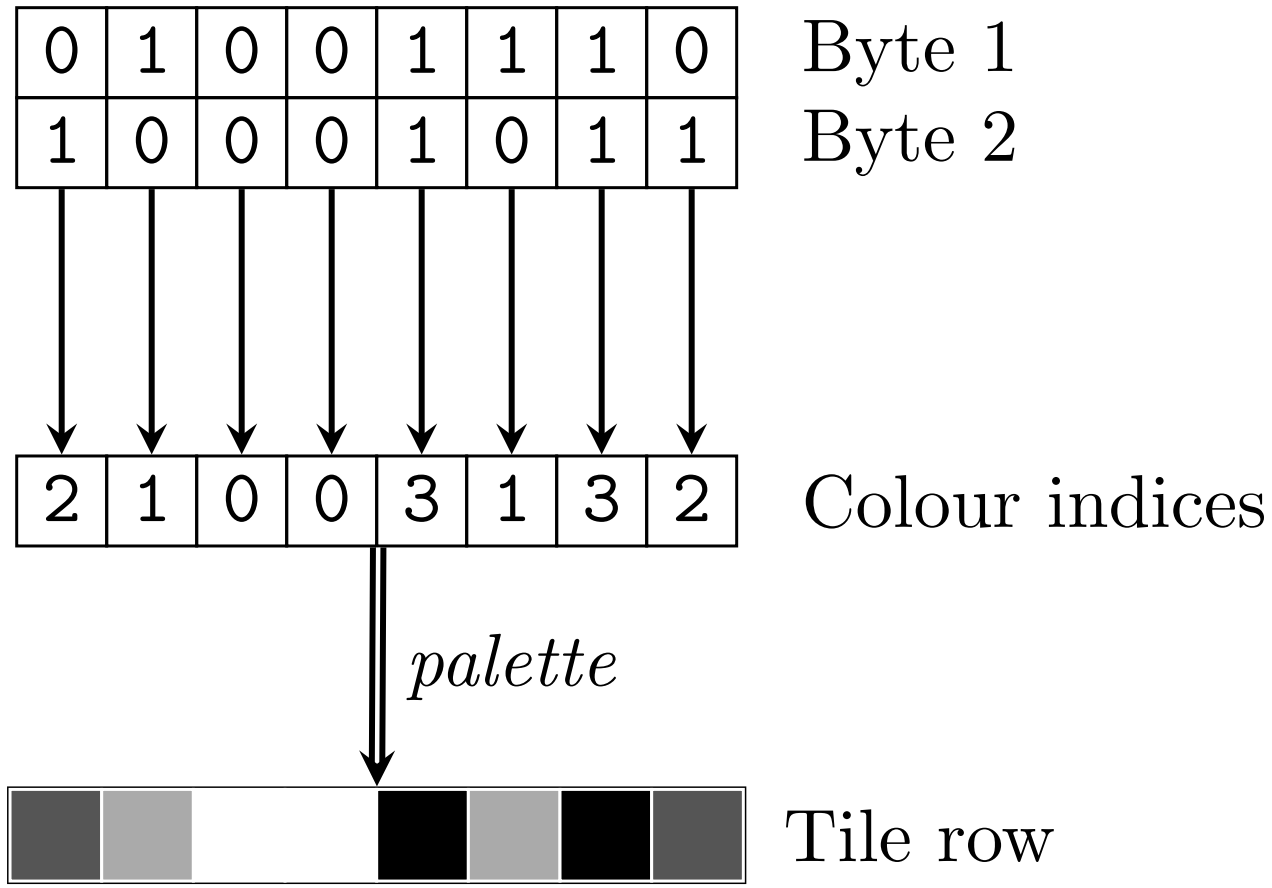
1.22 GameBoy Joypad Register




```
\tikzset{
        tablet/.style={
                matrix of nodes,
```

```
                row sep=-\pgflinewidth,
                column sep=-\pgflinewidth,
                nodes={rectangle,draw=black,text width=1.25ex,align=center},
                text height=1.25ex,
                text depth=0ex,
                nodes in empty cells
        },
        texto/.style={font=\footnotesize\sffamily},
        title/.style={font=\small\sffamily}
}

\begin{tikzpicture}[node distance=3cm, auto]
        \node [rectangle, draw, minimum width=5em, minimum height=7em] (joyp) {\tt JOYP};
        \matrix[tablet, draw=none, nodes={draw=none, inner sep = 0.16em}, inner sep=0.1em, left = -0.35cm
            of joyp] (pt)
        {
                \node (17){\scriptsize\tt 7}; \\ \node(16){\scriptsize\tt 6}; \\ \node(15){\scriptsize\tt
                    5}; \\ \node(14){\scriptsize\tt 4}; \\ \node(13){\scriptsize\tt 3}; \\ \node(12){\
                    scriptsize\tt 2}; \\ \node(11){\scriptsize\tt 1}; \\ \node(10){\scriptsize\tt 0};\\
        };

        \node [circle, inner sep=0, minimum size=0.25em, fill=black, left = 1.2cm of 10] (a) {};
        \node [circle, inner sep=0, minimum size=0.25em, fill=black, left = 1.2cm of 11] (b) {};
        \node [circle, inner sep=0, minimum size=0.25em, fill=black, left = 1.2cm of 12] (select) {};
        \node [circle, inner sep=0, minimum size=0.25em, fill=black, left = 1.2cm of 13] (start) {};

        \node [circle, inner sep=0, minimum size=0.25em, fill=black, left = 1cm of a] (right) {};
        \node [circle, inner sep=0, minimum size=0.25em, fill=black, left = 1cm of b] (left) {};
        \node [circle, inner sep=0, minimum size=0.25em, fill=black, left = 1cm of select] (up) {};
        \node [circle, inner sep=0, minimum size=0.25em, fill=black, left = 1cm of start] (down) {};

        \node [left = 0.5cm of right] (ra) {};
        \node [left = 0.5cm of left] (lb) {};
        \node [left = 0.5cm of up] (usel) {};
        \node [left = 0.5cm of down] (dst) {};

        \node [below = 0.15cm of a] (aa) {};
        \node [below = 0.15cm of right] (rr) {};

        \draw (ra) -- (right) -- (a) -- (10);
        \draw (lb) -- (left) -- (b) -- (11);
        \draw (usel) -- (up) -- (select) -- (12);
        \draw (dst) -- (down) -- (start) -- (13);

        \draw (aa) -- (a) -- node[right] {\tiny\bf A} (b) -- node[right] {\tiny\bf B} (select) -- node[
            right] {\tiny\bf SELECT} (start) |- node[pos=0.2, right] {\tiny\bf START} (14);
        \draw (rr) -- (right) -- node[right] {\tiny $\bm{\rightarrow}$} (left) -- node[right]{\tiny $\bm{\
            leftarrow}$} (up) -- node[right]{\tiny $\bm{\uparrow}$} (down) |- node[pos=0.1, right]{\tiny $\
            bm{\downarrow}$} (15);
\end{tikzpicture}
```

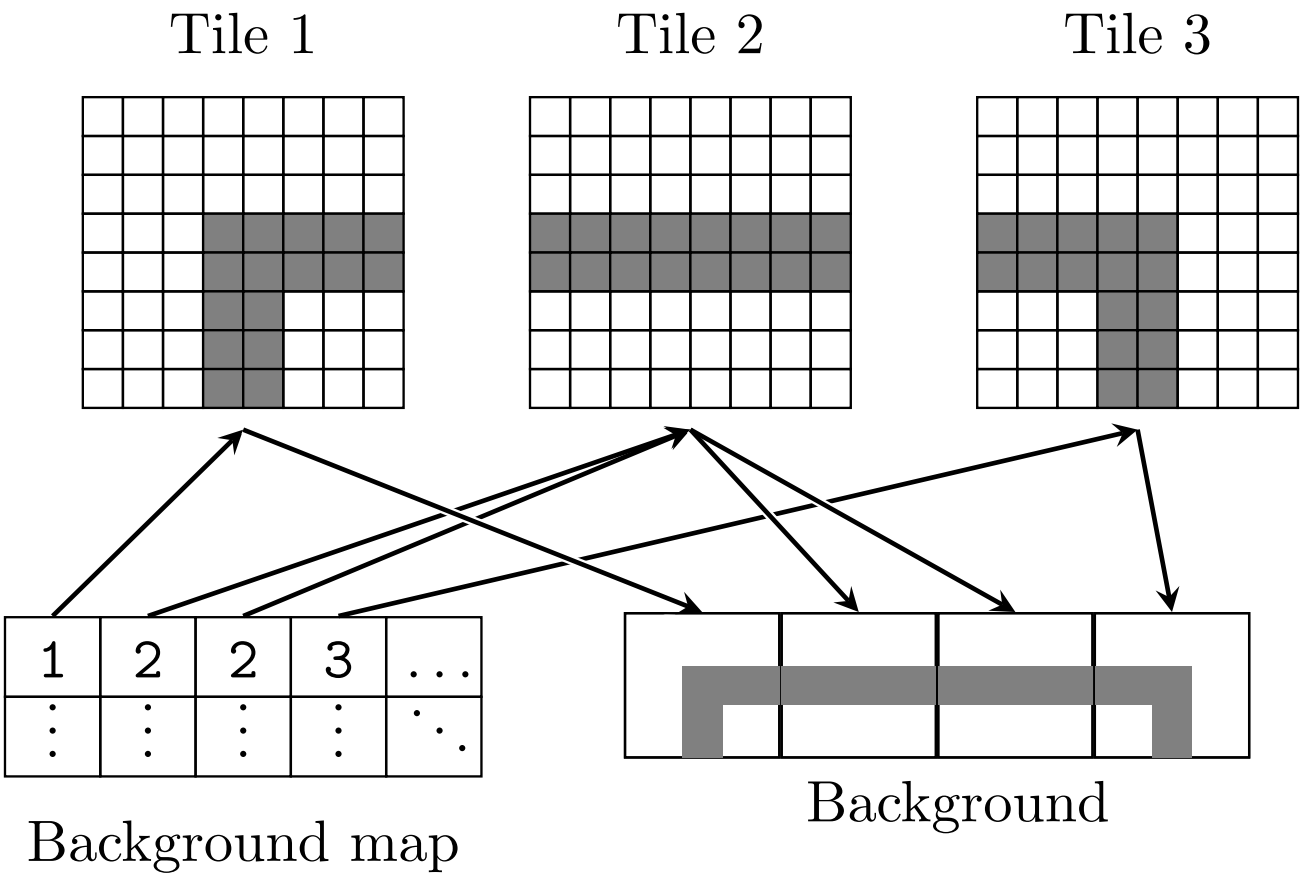
1.23 Gameboy Palette Translation




```
\tikzset{
        tablet/.style={
                matrix of nodes,
                row sep=-\pgflinewidth,
                column sep=-\pgflinewidth,
                nodes={rectangle,draw=black,text width=1.25ex,align=center},
                text height=1.25ex,
                nodes in empty cells
        },
        texto/.style={font=\footnotesize\sffamily},
        title/.style={font=\small\sffamily}
}

\definecolor{dgry}{HTML}{555555}
\definecolor{lgry}{HTML}{aaaaaa}

\begin{tikzpicture}
        \matrix[tablet] (mp)
        {
                {\tt 0} & {\tt 1} & {\tt 0} & {\tt 0} & {\tt 1} & {\tt 1} & {\tt 1} & {\tt 0}\\
                \node (00){\tt 1}; & \node(01){\tt 0}; & \node(02){\tt 0}; & \node(03){\tt 0}; & \node(04)
                    {\tt 1}; & \node(05){\tt 0}; & \node(06){\tt 1}; & \node(07){\tt 1};\\
        };

        \matrix[tablet, below = of mp] (pt)
        {
                \node (10){\tt 2}; & \node(11){\tt 1}; & \node(12){\tt 0}; & \node(13){\tt 0}; & \node(14)
                    {\tt 3}; & \node(15){\tt 1}; & \node(16){\tt 3}; & \node(17){\tt 2};\\
        };

        \matrix[tablet, draw=black, inner sep=0ex, nodes={draw=white,inner sep=0.8ex}, below = of pt] (clr)
        {
                |[fill=dgry]| & |[fill=lgry]| & |[fill=white]| & |[fill=white]| & |[fill=black]| & |[fill=
                    lgry]| & |[fill=black]| & |[fill=dgry]|\\
        };

        \node [align=center, right = 0.05cm of mp] (c1) {Byte 1 \\ Byte 2};
```

```
        \node [align=center, right = 0.05cm of pt] (c2) {Colour indices};
        \node [align=center, right = 0.05cm of clr] (c3) {Tile row};

        \draw [-stealth, thick] (00) -- (10)    ;
        \draw [-stealth, thick] (01) -- (11)    ;
        \draw [-stealth, thick] (02) -- (12)    ;
        \draw [-stealth, thick] (03) -- (13)    ;
        \draw [-stealth, thick] (04) -- (14)    ;
        \draw [-stealth, thick] (05) -- (15)    ;
        \draw [-stealth, thick] (06) -- (16)    ;
        \draw [-stealth, thick] (07) -- (17)    ;

        \draw [-stealth, double, thick] (13.south east) -- node[right] {\emph{palette}} (clr);
\end{tikzpicture}
```

1.24 Gameboy Tiling System



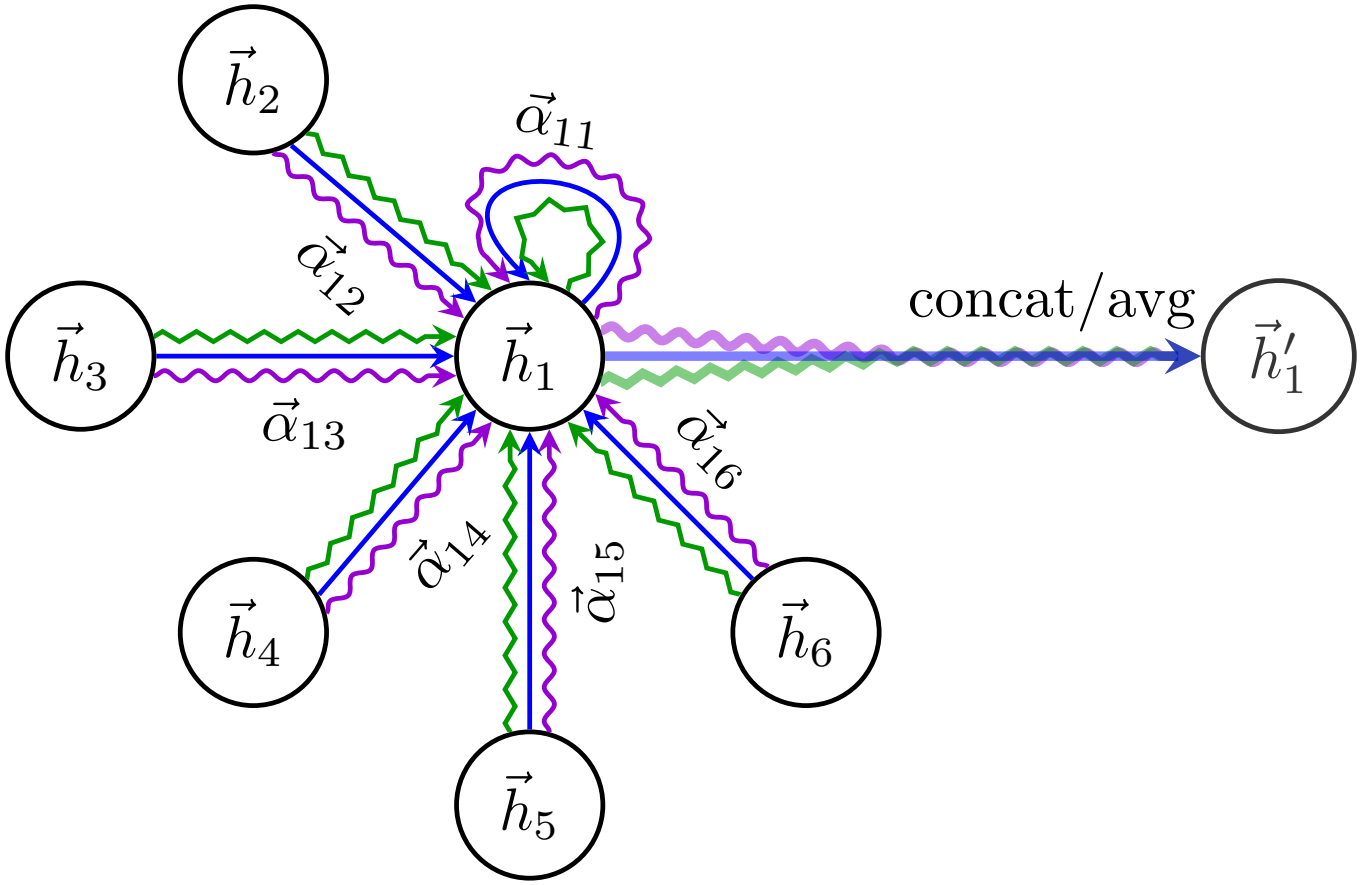

```
\tikzset{
        table/.style={
                matrix of nodes,
                row sep=-\pgflinewidth,
                column sep=-\pgflinewidth,
                nodes={rectangle,draw=black,text width=0.05ex,align=center},
                nodes in empty cells
        },
        texto/.style={font=\footnotesize\sffamily},
        title/.style={font=\small\sffamily}
}

\tikzset{
        tablet/.style={
                matrix of nodes,
                row sep=-\pgflinewidth,
                column sep=-\pgflinewidth,
                nodes={rectangle,draw=black,text width=2.25ex,align=center},
                text height=1.625ex,
                text depth=0ex,
                nodes in empty cells
```

```
        },
        texto/.style={font=\footnotesize\sffamily},
        title/.style={font=\small\sffamily}
}

\tikzset{
        tablett/.style={
                matrix of nodes,
                row sep=-\pgflinewidth,
                column sep=-\pgflinewidth,
                nodes={rectangle, text width=0.05ex,align=center},
                nodes in empty cells
        },
        texto/.style={font=\footnotesize\sffamily},
        title/.style={font=\small\sffamily}
}

\begin{tikzpicture}[node distance=0.5cm, auto]
        \matrix[table] (t1)
        {
                & & & & & & \\
                & & & & & & \\
                & & & & & & \\
                & & & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| \\
                & & & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| \\
                & & & |[fill=gray]| & |[fill=gray]| & & & \\
                & & & |[fill=gray]| & |[fill=gray]| & & & \\
                & & & |[fill=gray]| & |[fill=gray]| & & & \\
        };
        \node[above = 0.01cm of t1] (c1) {Tile 1};

        \matrix[table, right =of t1] (t2)
        {
                & & & & & & \\
                & & & & & & \\
                & & & & & & \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
                    ]| & |[fill=gray]| & |[fill=gray]| \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
                    ]| & |[fill=gray]| & |[fill=gray]|  \\
                & & & & & & \\
                & & & & & & \\
                & & & & & & \\
        };
        \node[above = 0.01cm of t2] (c2) {Tile 2};

        \matrix[table, right =of t2] (t3)
        {
                & & & & & & \\
                & & & & & & \\
                & & & & & & \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & & & \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & & & \\
                & & & |[fill=gray]| & |[fill=gray]| & & & \\
                & & & |[fill=gray]| & |[fill=gray]| & & & \\
                & & & |[fill=gray]| & |[fill=gray]| & & & \\
        };
        \node[above = 0.01cm of t3] (c3) {Tile 3};

        \matrix[tablet, below = 1cm of t1] (mp)
        {
                \node (1) {\tt 1}; & \node (2) {\tt 2}; & \node (22) {\tt 2}; & \node (3) {\tt 3}; & \dots
                    \\
                \vdots & \vdots & \vdots & \vdots & $\ddots$ \\
        };
        \node[below = 0.01cm of mp] (c4) {Background map};

        \draw [-stealth, thick] (1.north) -- (t1.south) ;
        \draw [-stealth, thick] (2.north) -- (t2.south);
        \draw [-stealth, thick] (22.north) -- (t2.south);
        \draw [-stealth, thick] (3.north) -- (t3.south);

        \matrix[tablett, rectangle, draw, scale=0.2, inner sep=0ex, nodes={inner sep=0.4ex}, below right =
            1.1cm and -1.5cm of t2] (bg1)
        {
                & & & & & & \\
```

```
        & & & & & & \\
        & & & & & & \\
        & & & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| \\
        & & & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| \\
        & & & |[fill=gray]| & |[fill=gray]| & & & \\
        & & & |[fill=gray]| & |[fill=gray]| & & & \\
        & & & |[fill=gray]| & |[fill=gray]| & & & \\
};

\matrix[tablett, rectangle, draw, scale=0.2, inner sep=0ex, nodes={inner sep=0.4ex}, right = 0cm of
    bg1] (bg2)
{
        & & & & & & \\
        & & & & & & \\
        & & & & & & \\
        |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
            ]| & |[fill=gray]| & |[fill=gray]| \\
        |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
            ]| & |[fill=gray]| & |[fill=gray]|  \\
        & & & & & & \\
        & & & & & & \\
        & & & & & & \\
};

\matrix[tablett, rectangle, draw, scale=0.2, inner sep=0ex, nodes={inner sep=0.4ex}, right = 0cm of
    bg2] (bg3)
{
        & & & & & & \\
        & & & & & & \\
        & & & & & & \\
        |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
            ]| & |[fill=gray]| & |[fill=gray]| \\
        |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
            ]| & |[fill=gray]| & |[fill=gray]|  \\
        & & & & & & \\
        & & & & & & \\
        & & & & & & \\
};

\matrix[tablett, rectangle, draw, scale=0.2, inner sep=0ex, nodes={inner sep=0.4ex}, right = 0cm of
    bg3] (bg4)
{
        & & & & & & \\
        & & & & & & \\
        & & & & & & \\
        |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & & & \\
        |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & & & \\
        & & & |[fill=gray]| & |[fill=gray]| & & & \\
        & & & |[fill=gray]| & |[fill=gray]| & & & \\
        & & & |[fill=gray]| & |[fill=gray]| & & & \\
};

\node[below right = 0.01cm and 0.03cm of bg1] (c5) {Background};

\draw [-stealth, white, ultra thick] (t1.south) -- (bg1.north)  ;
\draw [-stealth, white, ultra thick] (t2.south) -- (bg2.north);
\draw [-stealth, white, ultra thick] (t2.south) -- (bg3.north);
\draw [-stealth, thick] (t1.south) -- (bg1.north);
\draw [-stealth, thick] (t2.south) -- (bg2.north);
\draw [-stealth, thick] (t2.south) -- (bg3.north);
\draw [-stealth, thick] (t3.south) -- (bg4.north);
\matrix[tablett, rectangle, draw, scale=0.2, inner sep=0ex, nodes={inner sep=0.4ex}, below right =
    1.1cm and -1.5cm of t2] (bg1)
{
        & & & & & & \\
        & & & & & & \\
        & & & & & & \\
        & & & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| \\
        & & & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| \\
        & & & |[fill=gray]| & |[fill=gray]| & & & \\
        & & & |[fill=gray]| & |[fill=gray]| & & & \\
        & & & |[fill=gray]| & |[fill=gray]| & & & \\
};

\matrix[tablett, rectangle, draw, scale=0.2, inner sep=0ex, nodes={inner sep=0.4ex}, right = 0cm of
    bg1] (bg2)
```

```
        {
                & & & & & & \\
                & & & & & & \\
                & & & & & & \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
                    ]| & |[fill=gray]| & |[fill=gray]| \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
                    ]| & |[fill=gray]| & |[fill=gray]|  \\
                & & & & & & \\
                & & & & & & \\
                & & & & & & \\
        };

        \matrix[tablett, rectangle, draw, scale=0.2, inner sep=0ex, nodes={inner sep=0.4ex}, right = 0cm of
             bg2] (bg3)
        {
                & & & & & & \\
                & & & & & & \\
                & & & & & & \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
                    ]| & |[fill=gray]| & |[fill=gray]| \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray
                    ]| & |[fill=gray]| & |[fill=gray]|  \\
                & & & & & & \\
                & & & & & & \\
                & & & & & & \\
        };

        \matrix[tablett, rectangle, draw, scale=0.2, inner sep=0ex, nodes={inner sep=0.4ex}, right = 0cm of
             bg3] (bg4)
        {
                & & & & & & \\
                & & & & & & \\
                & & & & & & \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & & & \\
                |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & |[fill=gray]| & & & \\
                & & & |[fill=gray]| & |[fill=gray]| & & & \\
                & & & |[fill=gray]| & |[fill=gray]| & & & \\
                & & & |[fill=gray]| & |[fill=gray]| & & & \\
        };

\end{tikzpicture}
```

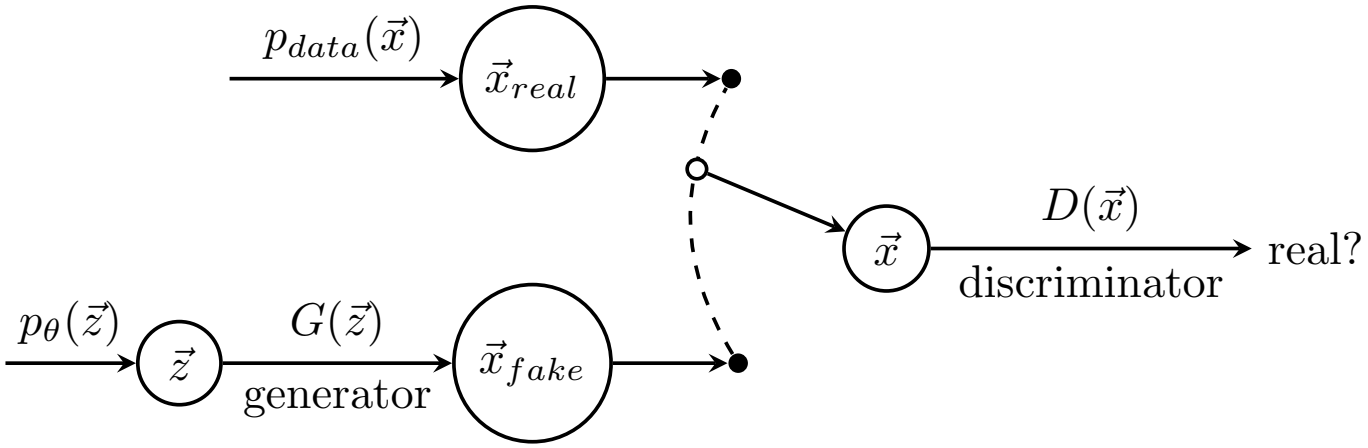
1.25 Gat Layer




```
\definecolor{mygreen}{rgb}{0,0.6,0}
\definecolor{mymauve}{rgb}{0.58,0,0.82}

\begin{tikzpicture}

        \node[circle, draw, thick] (h1) {$\vec{h}_1$};
        \node[circle, draw, thick, above left=of h1] (h4) {$\vec{h}_2$};
        \node[circle, draw, thick, left=5em of h1] (h5) {$\vec{h}_3$};
        \node[circle, draw, thick, below left=of h1] (h6) {$\vec{h}_4$};
        \node[circle, draw, thick, below=5em of h1] (h7) {$\vec{h}_5$};
        \node[circle, draw, thick, below right=of h1] (h8) {$\vec{h}_6$};

        \draw[-stealth, mymauve, thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude
            =0.3mm, post length=1.5mm}, decorate] (h8.120) -- node[sloped, above, black] {$\vec{\alpha
            }_{16}$} (h1.-30);
        \draw[-stealth, blue, thick] (h8.135) -- (h1.-45);
        \draw[-stealth, mygreen, thick, decoration={zigzag, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate] (h8.150) -- (h1.-60);

        \draw[-stealth, mymauve, thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude
            =0.3mm, post length=1.5mm}, decorate] (h1.30) to[looseness=7] node[sloped, above, black] {$\vec
            {\alpha}_{11}$}(h1.105);
        \draw[-stealth, blue, thick] (h1.45) to[looseness=9] (h1.90);
        \draw[-stealth, mygreen, thick, decoration={zigzag, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate] (h1.60) to[looseness=20] (h1.75);

        \draw[-stealth, mymauve, thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude
            =0.3mm, post length=1.5mm}, decorate] (h4.285) -- node[sloped, below, black] {$\vec{\alpha
            }_{12}$}(h1.150);
        \draw[-stealth, blue, thick] (h4.300) -- (h1.135);
        \draw[-stealth, mygreen, thick, decoration={zigzag, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate] (h4.315) -- (h1.120);

        \draw[-stealth, mymauve, thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude
            =0.3mm, post length=1.5mm}, decorate] (h5.-15) -- node[sloped, below, black] {$\vec{\alpha
            }_{13}$}(h1.195);
        \draw[-stealth, blue, thick] (h5.0) -- (h1.180);
        \draw[-stealth, mygreen, thick, decoration={zigzag, pre length=0.01mm, segment length=2mm,
```

```
            amplitude=0.3mm, post length=1.5mm}, decorate] (h5.15) -- (h1.165);

                \draw[-stealth, mymauve, thick,decoration={snake, pre length=0.01mm, segment length=2mm,
                    amplitude=0.3mm, post length=1.5mm}, decorate] (h6.15) -- node[sloped, below, black]
                    {$\vec{\alpha}_{14}$}(h1.240);
        \draw[-stealth, blue, thick] (h6.30) -- (h1.225);
        \draw[-stealth, mygreen, thick, decoration={zigzag, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate] (h6.45) -- (h1.210);

        \draw[-stealth, mymauve, thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude
            =0.3mm, post length=1.5mm}, decorate] (h7.75) -- node[sloped, below, black] {$\vec{\alpha
            }_{15}$}(h1.-75);
        \draw[-stealth, blue, thick] (h7.90) -- (h1.-90);
        \draw[-stealth, mygreen, thick, decoration={zigzag, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate] (h7.105) -- (h1.-105);

        \node[circle, draw, thick, right=10em of h1, opacity=0.8] (hp) {$\vec{h}_1'$};

        \coordinate[right=5em of h1] (A);

        \draw[-stealth,  mymauve, opacity=0.5, ultra thick,decoration={snake, pre length=0.01mm, segment
            length=2mm, amplitude=0.3mm, post length=1.5mm}, decorate] (h1.20) -- (A) -- (hp);
        \draw[-stealth, mygreen, opacity=0.5, ultra thick,decoration={zigzag, pre length=0.01mm, segment
            length=2mm, amplitude=0.3mm, post length=1.5mm}, decorate] (h1.-20) -- (A) -- (hp);
        \draw[-stealth, blue, opacity=0.5, ultra thick] (h1.0) -- (A) -- node[black, above, opacity=1.0] {
            concat/avg} (hp);

\end{tikzpicture}
```

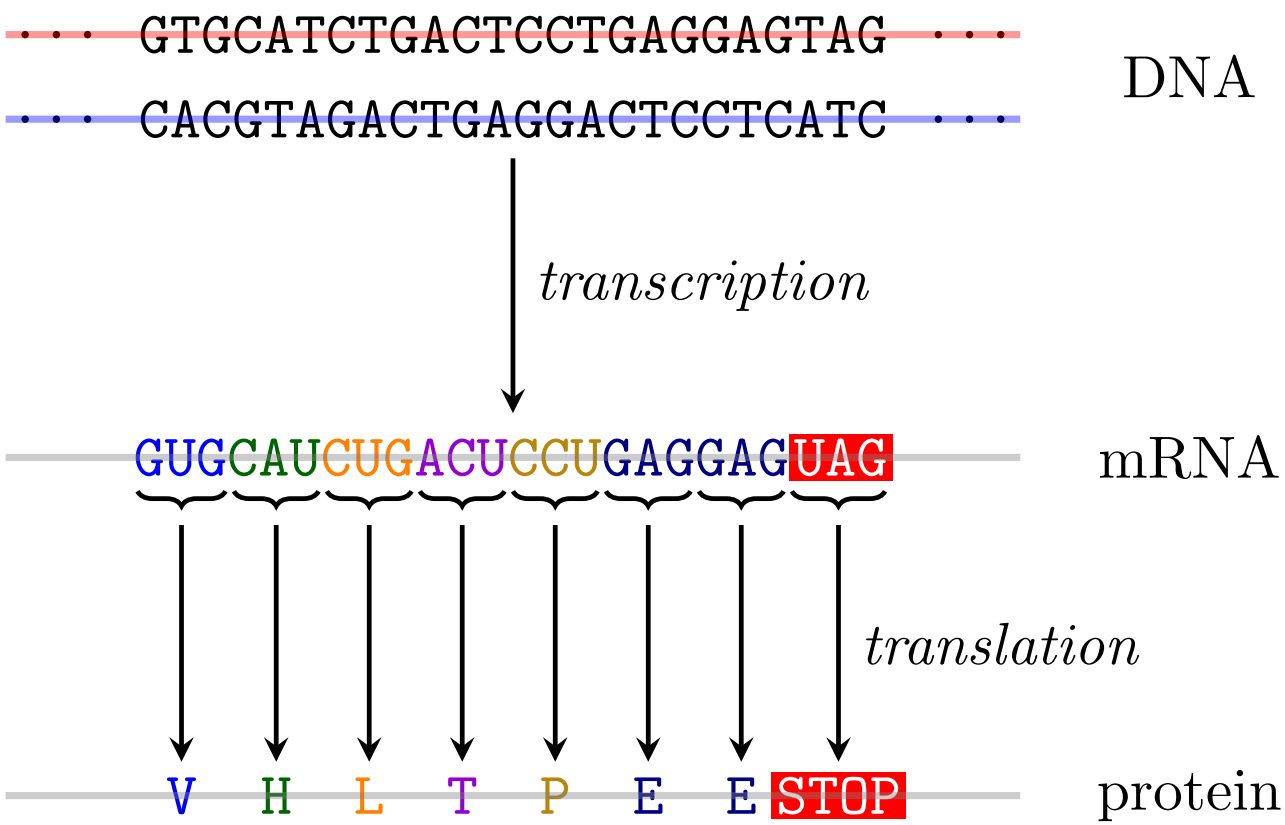
1.26 Generative Adversarial Network




```
\begin{tikzpicture}

        \node[circle, draw, thick] (z) {$\vec{z}$};
        \node[circle, draw, thick, right=5em of z] (x) {$\vec{x}_{fake}$};
        \draw[-stealth, thick] (z) -- node[above] {$G(\vec{z})$} node[below] {generator} (x);
        \node[left=of z] (i) {};
        \draw[-stealth, thick] (i) -- node[above] {$p_\theta(\vec{z})$} (z);
        \node[above=of x, circle, draw, thick] (xt) {$\vec{x}_{real}$};
        \node[left=5em of xt] (it) {};
        \draw[-stealth, thick] (it) -- node[above] {$p_{data}(\vec{x})$} (xt);
        \node[circle, draw, thick, right=5em of x, yshift=2.5em] (D) {$\vec{x}$};
        \node[right=7em of D] (out) {real?};
        \draw[-stealth, thick] (D) -- node[above] {$D(\vec{x})$} node[below] {discriminator} (out);

        \node[right=2.5em of x, circle, fill, inner sep=0.15em] (pt1) {};
        \node[right=2.5em of xt, circle, fill, inner sep=0.15em] (pt2) {};

        \draw[dashed, thick] (pt1) edge[bend left] (pt2);

        \node[circle, draw, thick, fill=white, inner sep=0.15em] at ([xshift=-0.9em, yshift=4em]pt1.north)
            (pt3) {};

        \draw[-stealth, thick] (x) -- (pt1);
        \draw[-stealth, thick] (xt) -- (pt2);
```

```
        \draw[-stealth, thick] (pt3) -- (D);

\end{tikzpicture}
```

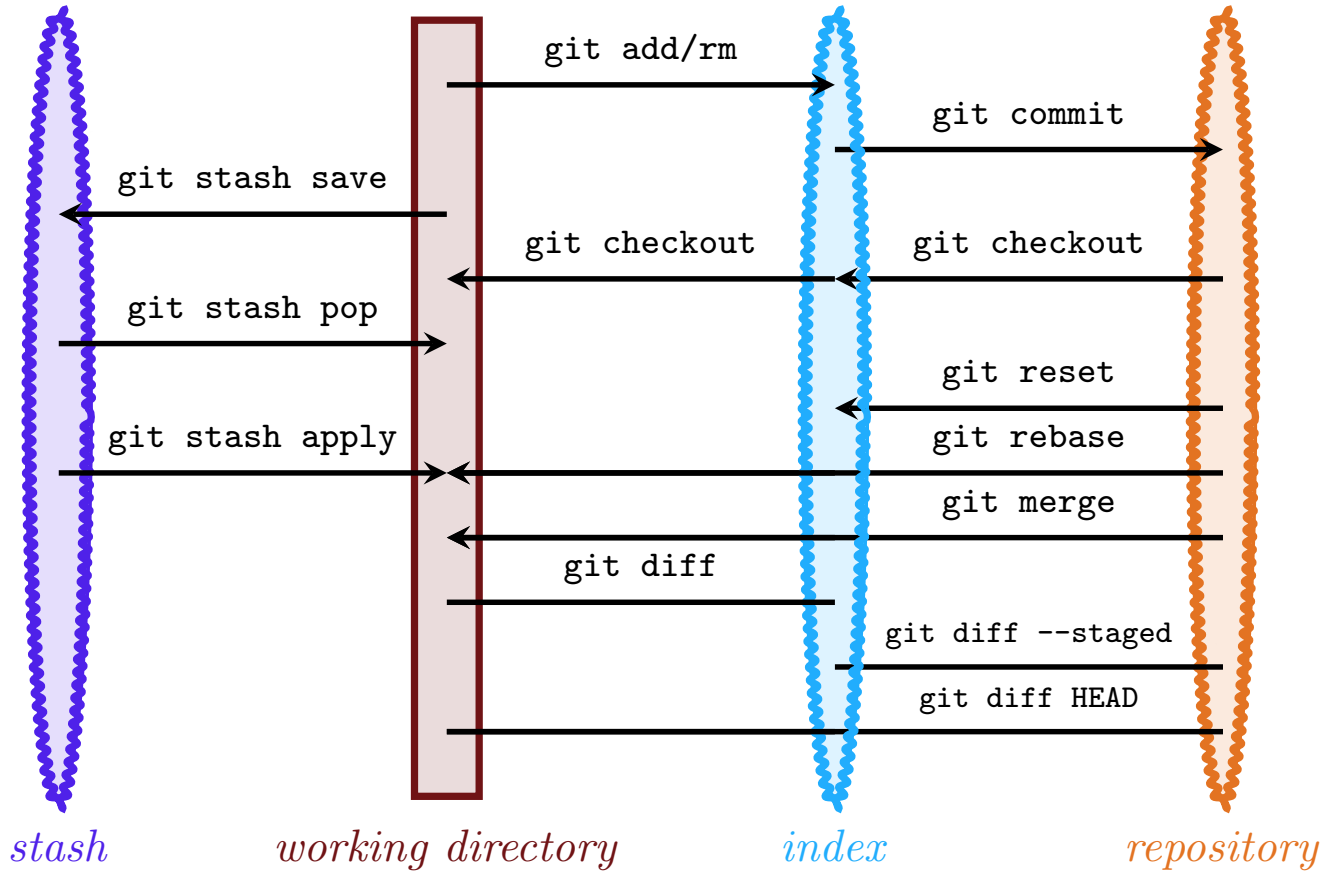
1.27 Gene Expression




```
\definecolor{mygreen}{HTML}{006400}
\definecolor{mymauve}{rgb}{0.58,0,0.82}
\definecolor{mygold}{HTML}{B8860B}
\definecolor{mynavy}{HTML}{000080}

\begin{tikzpicture}
        \node at (0,0) {\tt GTGCATCTGACTCCTGAGGAGTAG};
        \node (dnk2) at (0,-0.5) {\tt CACGTAGACTGAGGACTCCTCATC};
        \node at (-2.7, 0) {\tt \dots};
        \node at (2.7, 0) {\tt \dots};
        \node at (-2.7, -0.5) {\tt \dots};
        \node at (2.7, -0.5) {\tt \dots};
        \draw[red, opacity=0.4, very thick] (-3, 0) -- (3, 0);
        \draw[blue, opacity=0.4, very thick] (-3, -0.5) -- (3, -0.5);

        \node at (4, -0.25) {DNA};

        \node (rnk) at (0,-2.5) {\tt \textcolor{blue}{GUG}\textcolor{mygreen}{CAU}\textcolor{orange}{CUG}\
            textcolor{mymauve}{ACU}\textcolor{mygold}{CCU}\textcolor{mynavy}{GAGGAG}\tikz[baseline]{\node[
            rectangle, fill=red,inner sep=0.3mm,anchor=base] (X) {\textcolor{white}{UAG}};}};
        \draw[gray, opacity=0.4, very thick] (-3, -2.5) -- (3, -2.5);

        \draw [thick, decoration={ brace, mirror, raise=0.5cm}, decorate] (-2.22, -2.2) -- (-1.7, -2.2);
        \draw [thick, decoration={ brace, mirror, raise=0.5cm}, decorate] (-1.65, -2.2) -- (-1.15, -2.2);
        \draw [thick, decoration={ brace, mirror, raise=0.5cm}, decorate] (-1.1, -2.2) -- (-0.6, -2.2);
        \draw [thick, decoration={ brace, mirror, raise=0.5cm}, decorate] (-0.55, -2.2) -- (-0.05, -2.2);
        \draw [thick, decoration={ brace, mirror, raise=0.5cm}, decorate] (0, -2.2) -- (0.5, -2.2);
        \draw [thick, decoration={ brace, mirror, raise=0.5cm}, decorate] (0.55, -2.2) -- (1.05, -2.2);
        \draw [thick, decoration={ brace, mirror, raise=0.5cm}, decorate] (1.1, -2.2) -- (1.6, -2.2);
        \draw [thick, decoration={ brace, mirror, raise=0.5cm}, decorate] (1.65, -2.2) -- (2.2, -2.2);

        \node at (4, -2.5) {mRNA};
```

```
        \draw[-stealth, thick] (dnk2) -- node[right] {\emph{transcription}} (rnk);

        \draw[-stealth, thick] (-1.96, -2.9) -- (-1.96, -4.3);
        \node at (-1.96, -4.5) {\tt \textcolor{blue}V};

        \draw[-stealth, thick] (-1.4, -2.9) -- (-1.4, -4.3);
        \node at (-1.4, -4.5) {\tt \textcolor{mygreen}H};

        \draw[-stealth, thick] (-0.85, -2.9) -- (-0.85, -4.3);
        \node at (-0.85, -4.5) {\tt \textcolor{orange}L};

        \draw[-stealth, thick] (-0.3, -2.9) -- (-0.3, -4.3);
        \node at (-0.3, -4.5) {\tt \textcolor{mymauve}T};

        \draw[-stealth, thick] (0.25, -2.9) -- (0.25, -4.3);
        \node at (0.25, -4.5) {\tt \textcolor{mygold}P};

        \draw[-stealth, thick] (0.8, -2.9) -- (0.8, -4.3);
        \node at (0.8, -4.5) {\tt \textcolor{mynavy}E};

        \draw[-stealth, thick] (1.35, -2.9) -- (1.35, -4.3);
        \node at (1.35, -4.5) {\tt \textcolor{mynavy}E};

        \draw[-stealth, thick] (1.925, -2.9) -- node[right] {\emph{translation}} (1.925, -4.3);
        \node at (1.925, -4.5) {\tikz[baseline]{\node[rectangle, fill=red,inner sep=0.3mm,anchor=base] (X)
            {\textcolor{white}{\tt STOP}};}};

        \draw[gray, opacity=0.4, very thick] (-3, -4.5) -- (3, -4.5);

        \node at (4, -4.5) {protein};
\end{tikzpicture}
```

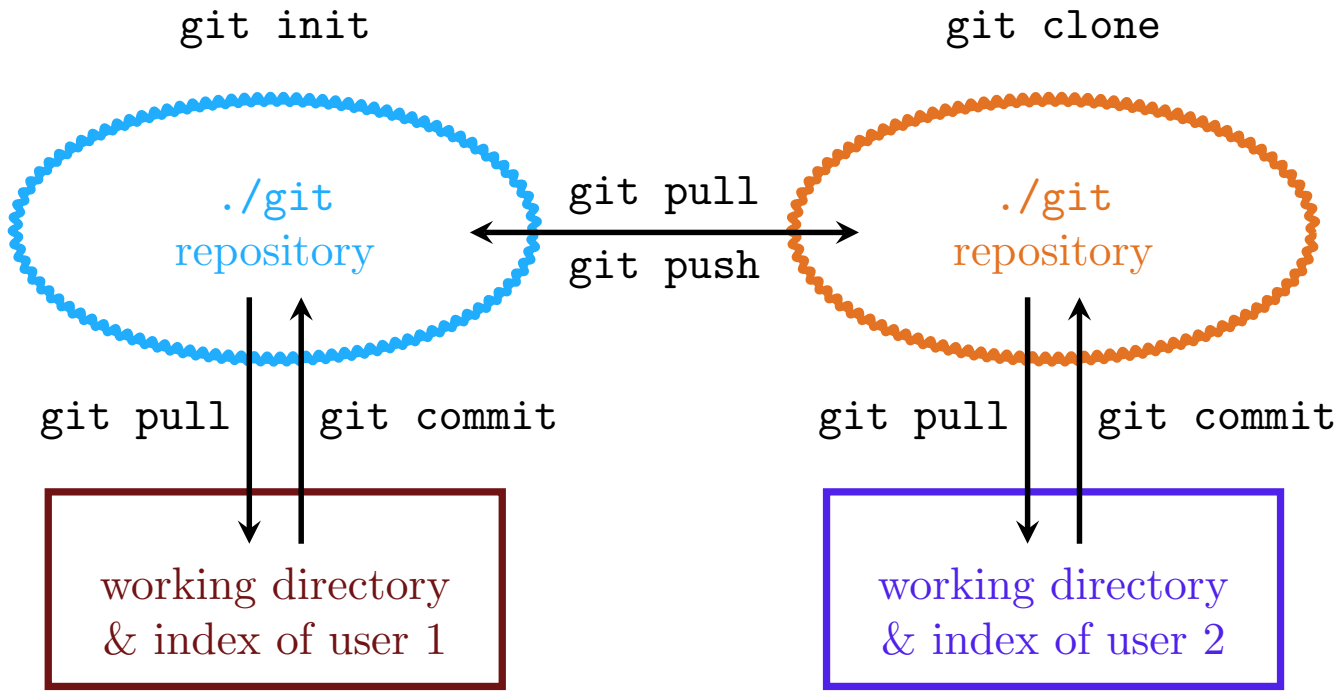
1.28 Git Dataflow




```
\definecolor{bluport}{HTML}{21ADFD}
\definecolor{orgport}{HTML}{E37322}
```

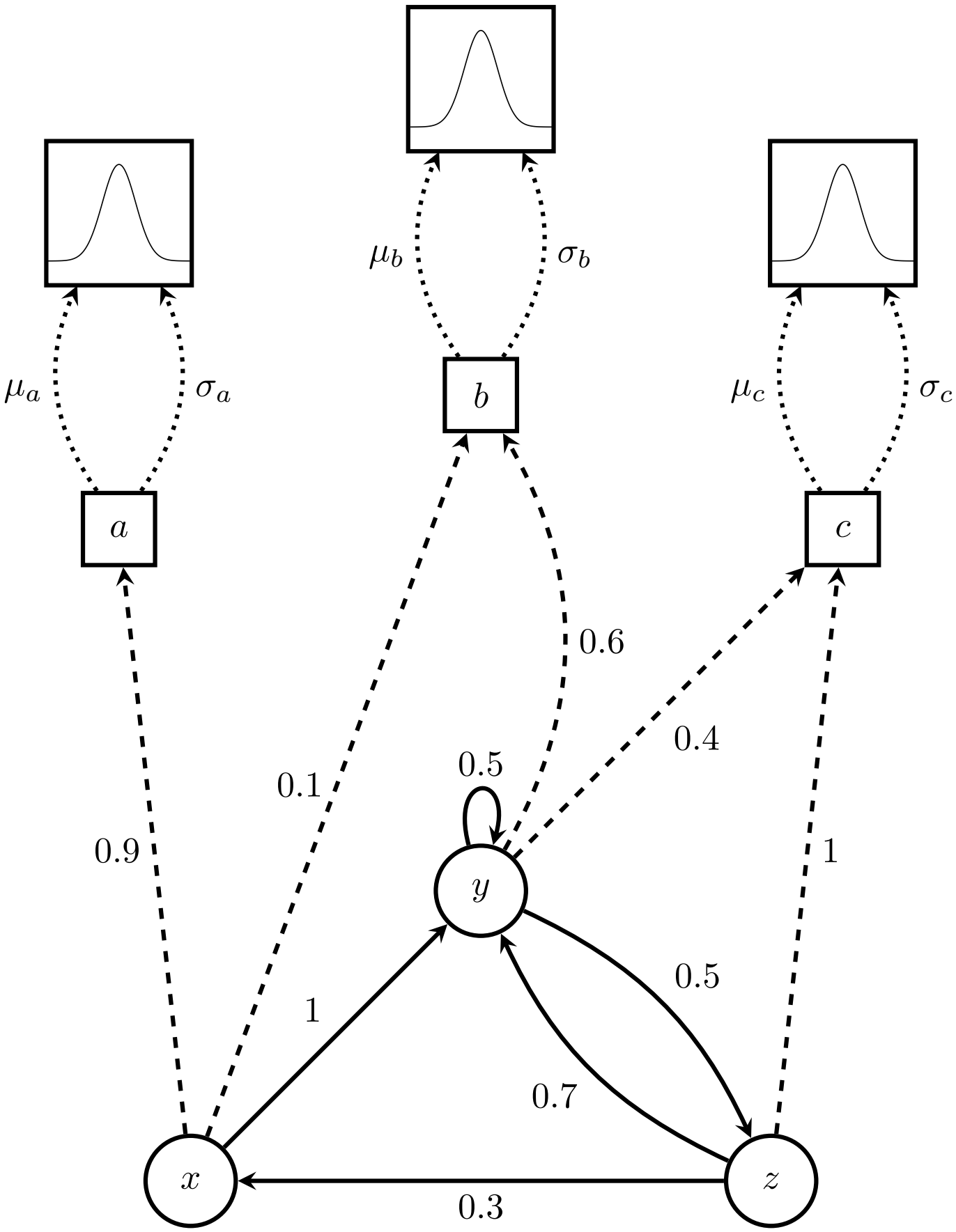
```
\definecolor{pplport}{HTML}{4F21E9}
\definecolor{redport}{HTML}{701315}

\begin{tikzpicture}

        \fill[pplport!15] (0, 0) ellipse (0.25 and 3);
        \fill[redport!15] (2.75, -3) rectangle (3.25, 3);
        \fill[bluport!15] (6, 0) ellipse (0.25 and 3);
        \fill[orgport!15] (9, 0) ellipse (0.25 and 3);

        \draw[thick, pplport] (0, 0) ellipse (0.25 and 3);
        \draw[ultra thick, pplport, decorate, decoration={snake, segment length=1mm, amplitude=0.3mm}] (0,
            0) ellipse (0.23 and 3.05);
        \node[text height=1em, text depth=1em, pplport] (1) at (0, -3.5) {\emph{stash}};

        \draw[ultra thick, redport] (2.75, -3) rectangle (3.25, 3);
        \node[text height=1em, text depth=1em, redport] (2) at (3, -3.5) {\emph{working directory}};

        \draw[thick, orgport] (9, 0) ellipse (0.25 and 3);
        \draw[ultra thick, orgport, decorate, decoration={snake, segment length=1mm, amplitude=0.3mm}] (9,
            0) ellipse (0.23 and 3.05);
        \node[text height=1em, text depth=1em, orgport] (4) at (9, -3.5) {\emph{repository}};

        \draw[-stealth, very thick] (6, 2) -- node[above] {\tt\footnotesize git commit} (9, 2);
        \draw[-stealth, very thick] (9, 1) -- node[above] {\tt\footnotesize git checkout} (6, 1);
        \draw[-stealth, very thick] (9, 0) -- node[above] {\tt\footnotesize git reset} (6, 0);
        \draw[very thick] (6, -2) -- node[above] {\tt\scriptsize git diff -{}-staged} (9, -2);
        \draw[very thick] (3, -2.5) -- node[above, pos=0.75] {\tt\scriptsize git diff HEAD} (9, -2.5);
        \draw[-stealth, very thick] (9, -0.5) -- node[above, pos=0.25] {\tt\footnotesize git rebase} (3,
            -0.5);
        \draw[-stealth, very thick] (9, -1) -- node[above, pos=0.25] {\tt\footnotesize git merge} (3, -1);

        % draw the blue portal here for the portal effect
        \draw[thick, bluport] (6, 0) ellipse (0.25 and 3);
        \draw[ultra thick, bluport, decorate, decoration={snake, segment length=1mm, amplitude=0.3mm}] (6,
            0) ellipse (0.23 and 3.05);
        \node[text height=1em, text depth=1em, bluport] (3) at (6, -3.5) {\emph{index}};

        % Redraw some lines for piercing effect through blu port
        \draw[-stealth, very thick] (6, -0.5) -- (3, -0.5);
        \draw[-stealth, very thick] (6, -1) -- (3, -1);
        \draw[very thick] (3, -2.5) -- (6, -2.5);

        \draw[-stealth, very thick] (3, 2.5) -- node[above] {\tt\footnotesize git add/rm} (6, 2.5);
        \draw[-stealth, very thick] (3, 1.5) -- node[above] {\tt\footnotesize git stash save} (0, 1.5);
        \draw[-stealth, very thick] (6, 1) -- node[above] {\tt\footnotesize git checkout} (3, 1);
        \draw[-stealth, very thick] (0, 0.5) -- node[above] {\tt\footnotesize git stash pop} (3, 0.5);
        \draw[-stealth, very thick] (0, -0.5) -- node[above] {\tt\footnotesize git stash apply} (3, -0.5);
        \draw[very thick] (3, -1.5) -- node[above] {\tt\footnotesize git diff} (6, -1.5);
\end{tikzpicture}
```

1.29 Git WorkFlow




```
\definecolor{bluport}{HTML}{21ADFD}
\definecolor{orgport}{HTML}{E37322}
\definecolor{pplport}{HTML}{4F21E9}
\definecolor{redport}{HTML}{701315}

\begin{tikzpicture}
        \draw[thick, bluport] (0, 0) ellipse (2 and 1);
        \draw[ultra thick, bluport, decorate, decoration={snake, segment length=1mm, amplitude=0.3mm}] (0,
            0) ellipse (2 and 1);
        \node[text height=1em, text depth=1em] (1) at (0, 1.5) {\tt git init};
        \node[text height=1em, text depth=1em, align=center, bluport] (1) at (0, -0.25) {\tt ./git \\
            repository};

        \draw[thick, orgport] (6, 0) ellipse (2 and 1);
        \draw[ultra thick, orgport, decorate, decoration={snake, segment length=1mm, amplitude=0.3mm}] (6,
            0) ellipse (2 and 1);
        \node[text height=1em, text depth=1em] (1) at (6, 1.5) {\tt git clone};
        \node[text height=1em, text depth=1em, align=center, orgport] (1) at (6, -0.25) {\tt ./git \\
            repository};

        \draw[ultra thick, redport] (-1.75, -2) rectangle (1.75, -3.5);
        \node[text height=1em, text depth=1em, align=center, redport] (1) at (0, -3.25) {working directory
            \\ \& index of user 1};

        \draw[ultra thick, pplport] (4.25, -2) rectangle (7.75, -3.5);
        \node[text height=1em, text depth=1em, align=center, pplport] (1) at (6, -3.25) {working directory
            \\ \& index of user 2};

        \draw[very thick, stealth-stealth] (1.5, 0) -- node[above] {\tt git pull} node[below] {\tt git push
            } (4.5, 0);

        \draw[very thick, -stealth] (-0.2, -0.5) -- node[left] {\tt git pull} (-0.2, -2.4);
        \draw[very thick, -stealth] (0.2, -2.4) -- node[right] {\tt git commit} (0.2, -0.5);

        \draw[very thick, -stealth] (5.8, -0.5) -- node[left] {\tt git pull} (5.8, -2.4);
        \draw[very thick, -stealth] (6.2, -2.4) -- node[right] {\tt git commit} (6.2, -0.5);
\end{tikzpicture}
```

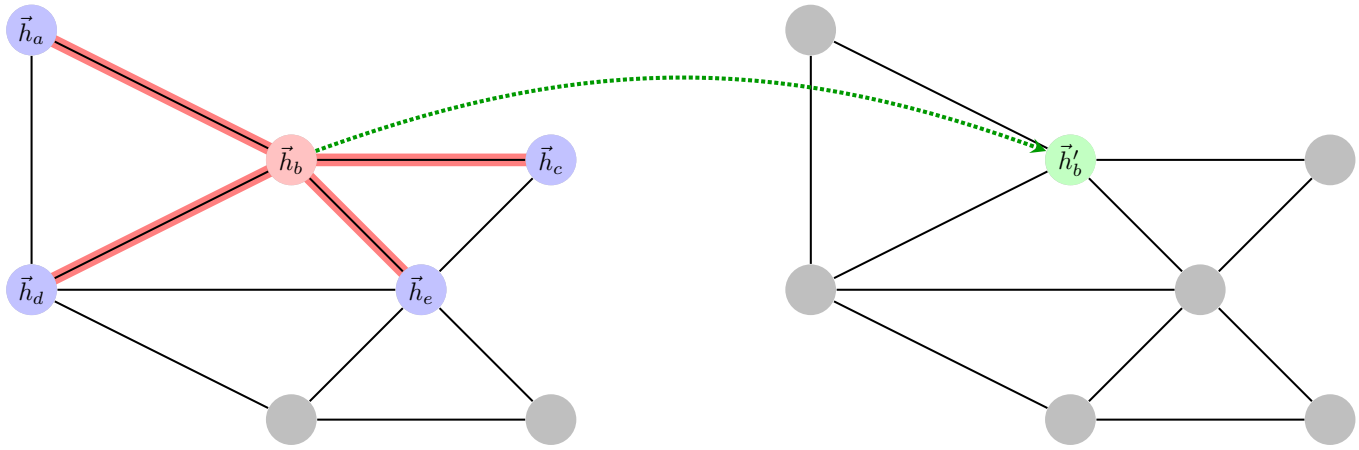
1.30 Gamhmm




```
\begin{tikzpicture}[-stealth,very thick,node distance = 4cm,auto]

        \node[state] (x) {$x$};
```

```
        \node[state] (y) [above right of=x] {$y$};
        \node[state] (z) [below right of=y] {$z$};

        \node[rectangle, minimum size=2em,draw] (a) [above left =of y] {$a$};
        \node[rectangle,minimum size=2em, draw] (b) [above = of y] {$b$};
        \node[rectangle, minimum size=2em,draw] (c) [above right =of y] {$c$};

        \draw[] (x) to node[above left] {$1$} (y);
        \draw[loop above] (y) to node {$0.5$} (y);
        \draw[bend left=20] (y) to node {$0.5$} (z);
        \draw[bend left=20] (z) to node[below left] {$0.7$} (y);
        \draw[] (z) to node {$0.3$} (x);

        \draw[dashed] (x) to node[left] {$0.9$} (a);
        \draw[dashed] (x) to node[left] {$0.1$} (b);
        \draw[bend right=30, dashed] (y) to node[right] {$0.6$} (b);
        \draw[dashed] (y) to node[below right] {$0.4$} (c);
        \draw[dashed] (z) to node[right] {$1$} (c);

        \node[rectangle, draw, scale=0.2, minimum size=20em,above = 2cm of a] (ga){\begin{tikzpicture}
                        \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                                \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                        \end{axis}
                \end{tikzpicture}};

        \node[rectangle, draw, scale=0.2, minimum size=20em,above = 2cm of b] (gb){\begin{tikzpicture}
                        \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                                \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                        \end{axis}
                \end{tikzpicture}};

        \node[rectangle, draw, scale=0.2, minimum size=20em,above = 2cm of c] (gc){\begin{tikzpicture}
                        \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                                \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                        \end{axis}
                \end{tikzpicture}};

        \draw[dotted, bend left] (a) to node[left] {$\mu_a$} (ga);
        \draw[dotted, bend right] (a) to node[right] {$\sigma_a$} (ga);
        \draw[dotted, bend left] (b) to node[left] {$\mu_b$} (gb);
        \draw[dotted, bend right] (b) to node[right] {$\sigma_b$} (gb);
        \draw[dotted, bend left] (c) to node[left] {$\mu_c$} (gc);
        \draw[dotted, bend right] (c) to node[right] {$\sigma_c$} (gc);

\end{tikzpicture}
```

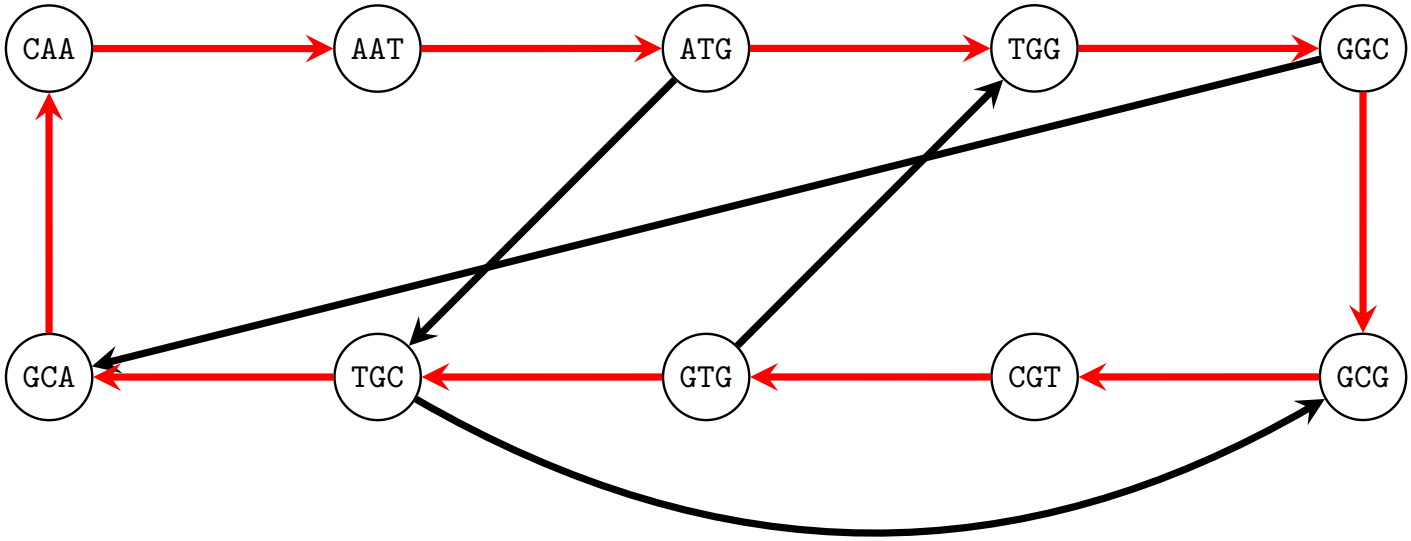
1.31 Graph Convolution




```
\definecolor{mygreen}{rgb}{0,0.6,0}

\pgfdeclarelayer{background}
\pgfsetlayers{background,main}

\tikzstyle{vertex}=[circle,fill=black!25,minimum size=20pt,inner sep=0pt]
\tikzstyle{selected vertex} = [vertex, fill=red!24]
```

```
\tikzstyle{select vertex} = [vertex, fill=blue!24]
\tikzstyle{selectx vertex} = [vertex, fill=green!24]
\tikzstyle{edge} = [draw,thick,-]
\tikzstyle{selected edge} = [draw,line width=5pt,-,red!50]


\begin{tikzpicture}[scale=1.8, auto,swap]
    \foreach \pos/\name in {{(0,2)/a}, {(2,1)/b}, {(4,1)/c},
                            {(0,0)/d}, {(3,0)/e}, {(2,-1)/f}, {(4,-1)/g}}
        \node[vertex] (\name) at \pos {};

    \foreach \source/ \dest /\weight in {b/a/7, c/b/8,d/a/5,d/b/9,
                                         e/b/7, e/c/5,e/d/15,
                                         f/d/6,f/e/8,
                                         g/e/9,g/f/11}
        \path[edge] (\source) -- (\dest);

    \foreach \vertex / \fr in {b/4}
        \path node[selected vertex] at (\vertex) {$\vec{h}_b$};
    \foreach \vertex / \fr in {a/4, c/4, d/4, e/5}
        \path node[select vertex] at (\vertex) {$\vec{h}_{\vertex}$};
    \begin{pgfonlayer}{background}
        \foreach \source / \dest in {b/c,d/b,a/b,b/e}
            \path[selected edge] (\source.center) -- (\dest.center);
    \end{pgfonlayer}

    \foreach \pos/\name in {{(6,2)/a1}, {(8,1)/b1}, {(10,1)/c1},
                            {(6,0)/d1}, {(9,0)/e1}, {(8,-1)/f1}, {(10,-1)/g1}}
        \node[vertex] (\name) at \pos {};
    \foreach \source/ \dest /\weight in {b1/a1/7, c1/b1/8,d1/a1/5,d1/b1/9,
                                         e1/b1/7, e1/c1/5,e1/d1/15,
                                         f1/d1/6,f1/e1/8,
                                         g1/e1/9,g1/f1/11}
        \path[edge] (\source) -- (\dest);
    \foreach \vertex / \fr in {b1/4}
        \path node[selectx vertex] at (\vertex) {$\vec{h}'_b$};

    \draw[-stealth, densely dotted, ultra thick, mygreen] (b) edge[bend left=20] (b1);
\end{tikzpicture}
```

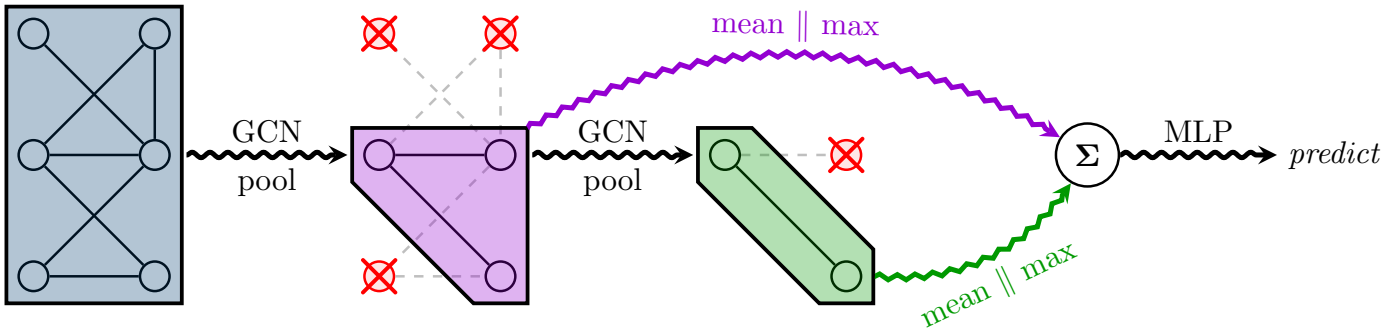
1.32 Hamitonian Graph




```
\begin{tikzpicture}[scale=0.8,every node/.style={scale=0.7},font=\tt]
        \SetUpEdge[lw         = 1.5pt,
                   color      = red,
                   labelcolor = white]
        \GraphInit[vstyle=Normal]
        \SetGraphUnit{3}
        \tikzset{VertexStyle/.append  style={fill}}
        \Vertex{ATG}
```

```
        \EA(ATG){TGG}
        \EA(TGG){GGC}
        \SO(GGC){GCG}
        \WE(GCG){CGT}
        \WE(CGT){GTG}
        \WE(GTG){TGC}
        \WE(TGC){GCA}
        \NO(GCA){CAA}
        \EA(CAA){AAT}
        \tikzset{EdgeStyle/.style={-stealth, color=black}}
        \Edge(ATG)(TGC)
        \Edge(GTG)(TGG)
        \Edge(GGC)(GCA)
        \tikzset{EdgeStyle/.style={-stealth, color=black, bend right}}
        \Edge(TGC)(GCG)
        \tikzset{EdgeStyle/.style={-stealth}}
        \Edge(ATG)(TGG)
        \Edge(TGG)(GGC)
        \Edge(GGC)(GCG)
        \Edge(GCG)(CGT)
        \Edge(CGT)(GTG)
        \Edge(GTG)(TGC)
        \Edge(TGC)(GCA)
        \Edge(GCA)(CAA)
        \Edge(CAA)(AAT)
        \Edge(AAT)(ATG)
\end{tikzpicture}
```

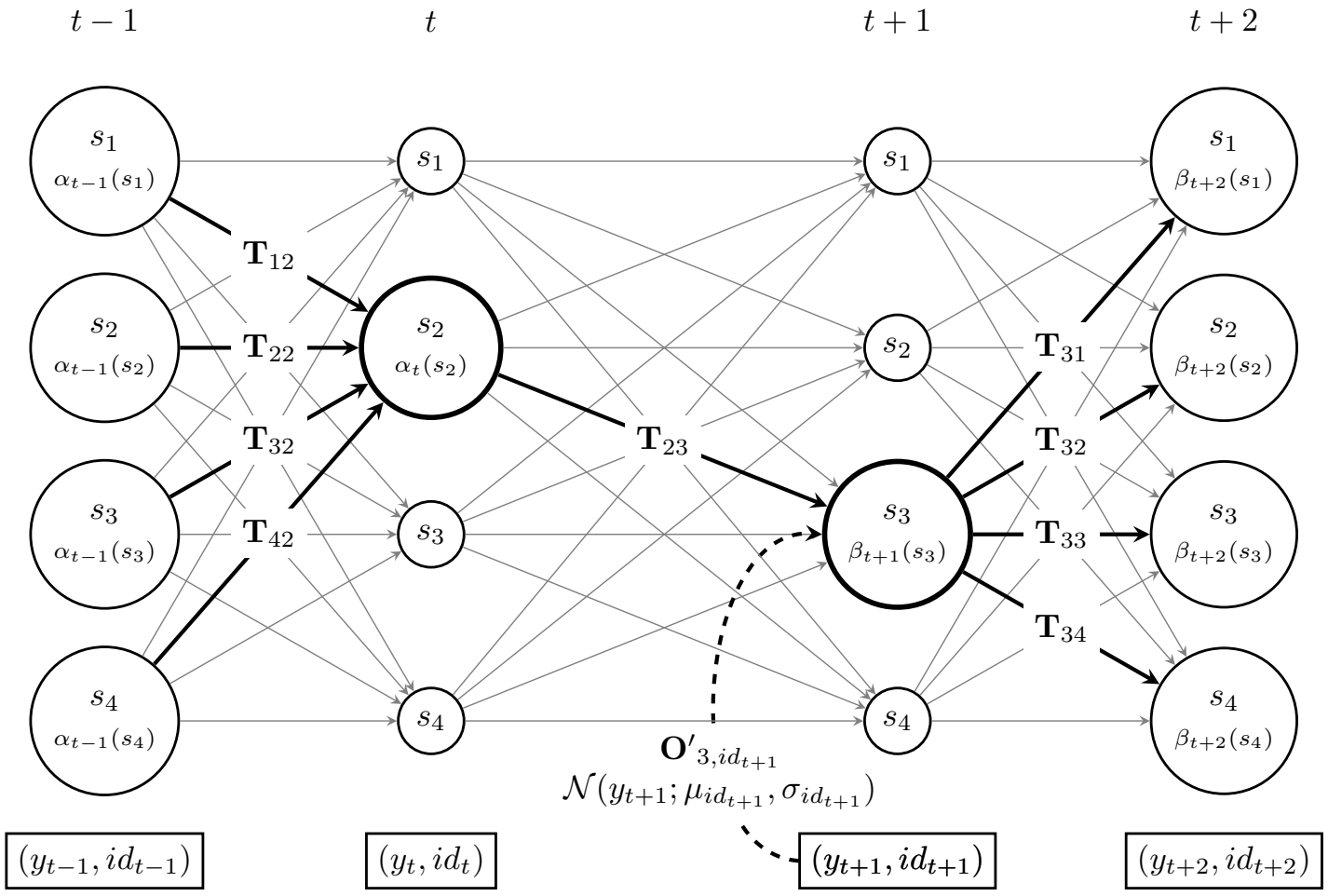
1.33 Hierachical Graph Classifier




```
\definecolor{mygreen}{rgb}{0,0.6,0}
\definecolor{mymauve}{rgb}{0.58,0,0.82}
\definecolor{camdrk}{RGB}{0,62,114}

\begin{tikzpicture}

        \node[circle, draw, thick] (h1) {};
        \node[circle, draw, thick, right=of h1] (h2) {};
        \node[circle, draw, thick, below=of h1] (h3) {};
        \node[circle, draw, thick, right=of h3] (h4) {};
        \node[circle, draw, thick, below=of h3] (h5) {};
        \node[circle, draw, thick, right=of h5] (h6) {};

        \draw[-, thick] (h1) -- (h4);
        \draw[-, thick] (h2) -- (h3);
        \draw[-, thick] (h2) -- (h4);
        \draw[-, thick] (h3) -- (h4);
        \draw[-, thick] (h3) -- (h6);
        \draw[-, thick] (h4) -- (h5);
        \draw[-, thick] (h5) -- (h6);

        \path [draw=black, smooth, fill=camdrk, fill opacity=0.3, very thick]
       ([xshift=-0.5em,yshift=0.5em]h1.north west) -- ([xshift=0.5em,yshift=0.5em]h2.north east) -- ([
           xshift=0.5em,yshift=-0.5em]h6.south east) -- ([xshift=-0.5em,yshift=-0.5em]h5.south west) --
           cycle;

        \node[circle, draw, thick, red, fill=red!10, right=10em of h1] (g1) {};
        \node[circle, draw, thick, red, fill=red!10, right=of g1] (g2) {};
        \node[circle, draw, thick, below=of g1] (g3) {};
```

```
        \node[circle, draw, thick, right=of g3] (g4) {};
        \node[circle, draw, thick, red, fill=red!10, below=of g3] (g5) {};
        \node[circle, draw, thick, right=of g5] (g6) {};

        \draw[-, thick, dashed, lightgray] (g1) -- (g4);
        \draw[-, thick, dashed, lightgray] (g2) -- (g3);
        \draw[-, thick, dashed, lightgray] (g2) -- (g4);
        \draw[-, thick] (g3) -- (g4);
        \draw[-, thick] (g3) -- (g6);
        \draw[-, thick, dashed, lightgray] (g4) -- (g5);
        \draw[-, thick, dashed, lightgray] (g5) -- (g6);

        \node[red] (icr) at (g1) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
            }}}}}}$};
        \node[red] (icr) at (g2) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
            }}}}}}$};
        \node[red] (icr) at (g5) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
            }}}}}}$};

        \path [draw=black, smooth, fill=mymauve, fill opacity=0.3, very thick]
       ([xshift=-0.5em,yshift=0.5em]g3.north west) -- ([xshift=0.5em,yshift=0.5em]g4.north east) -- ([
           xshift=0.5em,yshift=-0.5em]g6.south east) -- ([xshift=-0.5em,yshift=-0.5em]g6.south west) -- ([
           xshift=-0.5em,yshift=-0.5em]g3.south west) -- cycle;

        \node[circle, thick, right=10em of g1] (i1) {};
        \node[circle, thick, right=of i1] (i2) {};
        \node[circle, draw, thick, below=of i1] (i3) {};
        \node[circle, draw, red, thick, fill=red!10, right=of i3] (i4) {};
        \node[circle, thick, below=of i3] (i5) {};
        \node[circle, draw, thick, right=of i5] (i6) {};

        \draw[-, thick, dashed, lightgray] (i3) -- (i4);
        \draw[-, thick] (i3) -- (i6);

        \node[red] (icr) at (i4) {$\mathlarger{\mathlarger{\mathlarger{\mathlarger{\mathlarger{\bm{\times
            }}}}}}$};

        \draw[-stealth, ultra thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate] ([xshift=0.5em]h4.east) -- node[below, black] {pool} node[
            above] {GCN} ([xshift=-0.5em]g3.west);
        \draw[-stealth, ultra thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate] ([xshift=0.5em]g4.east) -- node[above] {GCN} node[below] {
            pool}([xshift=-0.5em]i3.west);

        \path [draw=black, smooth, fill=mygreen, fill opacity=0.3, very thick]
       ([xshift=-0.5em,yshift=0.5em]i3.north west) -- ([xshift=0.5em,yshift=0.5em]i3.north east) --([xshift
           =0.5em,yshift=0.5em]i6.north east) --([xshift=0.5em,yshift=-0.5em]i6.south east) -- ([xshift
           =-0.5em,yshift=-0.5em]i6.south west) -- ([xshift=-0.5em,yshift=-0.5em]i3.south west) -- cycle;

    \node[circle, draw, thick, right=10em of i3] (S) {$\boldsymbol\Sigma$};

    \path[-stealth, mymauve, ultra thick] ([xshift=0.5em, yshift=0.5em]g4.north east) edge[bend left,
        decoration={zigzag, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post length=1.5mm},
        decorate] node[sloped,above] {mean $\|$ max} (S);


    \path[-stealth, mygreen, ultra thick] ([xshift=0.4em]i6.east) edge[bend right,decoration={zigzag, pre
        length=0.01mm, segment length=2mm, amplitude=0.3mm, post length=1.5mm}, decorate] node[sloped,below
        ] {mean $\|$ max} (S);

    \node[right=5em of S] (P) {\emph{predict}};

        \draw[-stealth, ultra thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate] (S.east) --node[above] {MLP} (P.west);

\end{tikzpicture}
```

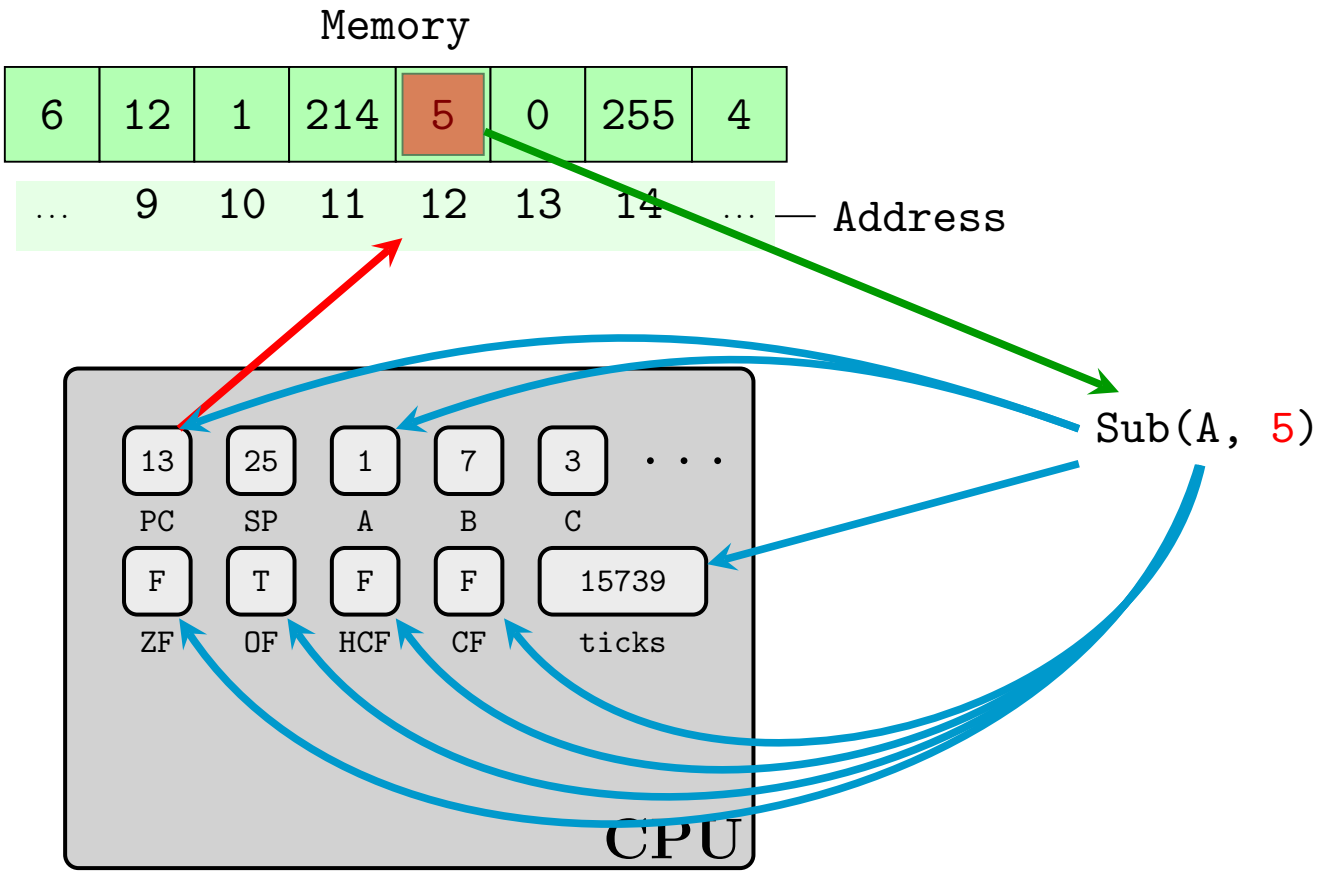
1.34 Hmm Transition Smoothing




```
\begin{tikzpicture}

        % 1st column
        \node at (0,6.5) {$t-1$};
        \node[align=center, circle, draw, thick] (s1_1) at (0,5) {$s_1$\\{\scriptsize$\alpha_{t-1}(s_1)$}};
        \node[align=center, circle, draw, thick] (s2_1) at (0,3) {$s_2$\\{\scriptsize$\alpha_{t-1}(s_2)$}};
        \node[align=center, circle, draw, thick] (s3_1) at (0,1) {$s_3$\\{\scriptsize$\alpha_{t-1}(s_3)$}};
        \node[align=center, circle, draw, thick] (s4_1) at (0,-1) {$s_4$\\{\scriptsize$\alpha_{t-1}(s_4)
            $}};
        \node [draw, thick] at (0,-2.5) {$(y_{t-1}, id_{t-1})$};

        % 2nd column
        \node at (3.5,6.5) {$t$};
        \node[circle, draw, thick] (s1_2) at (3.5,5) {$s_1$}
                edge[gray, thin, stealth-] (s1_1)
                edge[gray, thin, stealth-] (s2_1)
                edge[gray, thin, stealth-] (s3_1)
                edge[gray, thin, stealth-] (s4_1);
        \node[circle, draw, thick] (s3_2) at (3.5,1) {$s_3$}
                edge[gray, thin, stealth-] (s1_1)
                edge[gray, thin, stealth-] (s2_1)
                edge[gray, thin, stealth-] (s3_1)
                edge[gray, thin, stealth-] (s4_1);
        \node[circle, draw, thick] (s4_2) at (3.5,-1) {$s_4$}
                edge[gray, thin, stealth-] (s1_1)
                edge[gray, thin, stealth-] (s2_1)
                edge[gray, thin, stealth-] (s3_1)
                edge[gray, thin, stealth-] (s4_1);
        \node[align=center, circle, draw, ultra thick, minimum size=4.25em] (s2_2) at (3.5,3) {$s_2$\\{\
            scriptsize$\alpha_{t}(s_2)$}};

        % 3rd column
        \node [] (asdf2) at (8.5,-2.5) {$(y_{t+1}, id_{t+1})$};
        \node [draw, thick] (asdf3) at (12,-2.5) {$(y_{t+2}, id_{t+2})$};
```

```
        \node[align=center, circle, draw, ultra thick, minimum size=4.25em] (s3_3) at (8.5,1) {$s_3$\\{\
            scriptsize$\beta_{t+1}(s_3)$}}
                edge[gray, thin, stealth-] (s1_2)
                edge[gray, thin, stealth-] (s3_2)
                edge[gray, thin, stealth-] (s4_2);
        \draw[-stealth, very thick, dashed, bend left=90] (asdf2.west) to node[pos=0.33, align=center, fill
            =white] {${\bf O'}_{3,id_{t+1}}$\\$\mathcal{N}(y_{t+1};\mu_{id_{t+1}},\sigma_{id_{t+1}})$} (s
            3_3.west);
        \node [draw, thick] (asdf2) at (8.5,-2.5) {$(y_{t+1}, id_{t+1})$};
        \node at (8.5,6.5) {$t+1$};
        \node[circle, draw, thick] (s1_3) at (8.5,5) {$s_1$}
                edge[gray, thin, stealth-] (s1_2)
                edge[gray, thin, stealth-] (s2_2)
                edge[gray, thin, stealth-] (s3_2)
                edge[gray, thin, stealth-] (s4_2);
        \node[circle, draw, thick] (s2_3) at (8.5,3) {$s_2$}
                edge[gray, thin, stealth-] (s1_2)
                edge[gray, thin, stealth-] (s2_2)
                edge[gray, thin, stealth-] (s3_2)
                edge[gray, thin, stealth-] (s4_2);
        \node[circle, draw, thick] (s4_3) at (8.5,-1) {$s_4$}
                edge[gray, thin, stealth-] (s1_2)
                edge[gray, thin, stealth-] (s2_2)
                edge[gray, thin, stealth-] (s3_2)
                edge[gray, thin, stealth-] (s4_2);

        % 4th column
        \node at (12,6.5) {$t+2$};
        \node[align=center, circle, draw, thick] (s1_4) at (12,5) {$s_1$\\{\scriptsize$\beta_{t+2}(s_1)$}}
                edge[gray, thin, stealth-] (s1_3)
                edge[gray, thin, stealth-] (s2_3)
                edge[gray, thin, stealth-] (s4_3);
        \node[align=center, circle, draw, thick] (s2_4) at (12,3) {$s_2$\\{\scriptsize$\beta_{t+2}(s_2)$}}
                edge[gray, thin, stealth-] (s1_3)
                edge[gray, thin, stealth-] (s2_3)
                edge[gray, thin, stealth-] (s4_3);
        \node[align=center, circle, draw, thick] (s3_4) at (12,1) {$s_3$\\{\scriptsize$\beta_{t+2}(s_3)$}}
                edge[gray, thin, stealth-] (s1_3)
                edge[gray, thin, stealth-] (s2_3)
                edge[gray, thin, stealth-] (s4_3);
        \node[align=center, circle, draw, thick] (s4_4) at (12,-1) {$s_4$\\{\scriptsize$\beta_{t+2}(s_4)$}}
                edge[gray, thin, stealth-] (s1_3)
                edge[gray, thin, stealth-] (s2_3)
                edge[gray, thin, stealth-] (s4_3);
        \draw[very thick, stealth-] (s2_2) to node [midway, fill=white] {${\bf T}_{12}$} (s1_1);
        \draw[very thick, stealth-] (s2_2) to node [midway, fill=white] {${\bf T}_{22}$} (s2_1);
        \draw[very thick, stealth-] (s2_2) to node [midway, fill=white] {${\bf T}_{32}$} (s3_1);
        \draw[very thick, stealth-] (s2_2) to node [midway, fill=white] {${\bf T}_{42}$} (s4_1);
        \draw[very thick, stealth-] (s1_4) to node [midway, fill=white] {${\bf T}_{31}$} (s3_3);
        \draw[very thick, stealth-] (s2_4) to node [midway, fill=white] {${\bf T}_{32}$} (s3_3);
        \draw[very thick, stealth-] (s3_4) to node [midway, fill=white] {${\bf T}_{33}$} (s3_3);
        \draw[very thick, stealth-] (s4_4) to node [midway, fill=white] {${\bf T}_{34}$} (s3_3);
        \draw[very thick, stealth-] (s3_3) to node [midway, fill=white] {${\bf T}_{23}$} (s2_2);
        \node [draw, thick] (asdf) at (3.5,-2.5) {$(y_{t}, id_{t})$};

\end{tikzpicture}
```

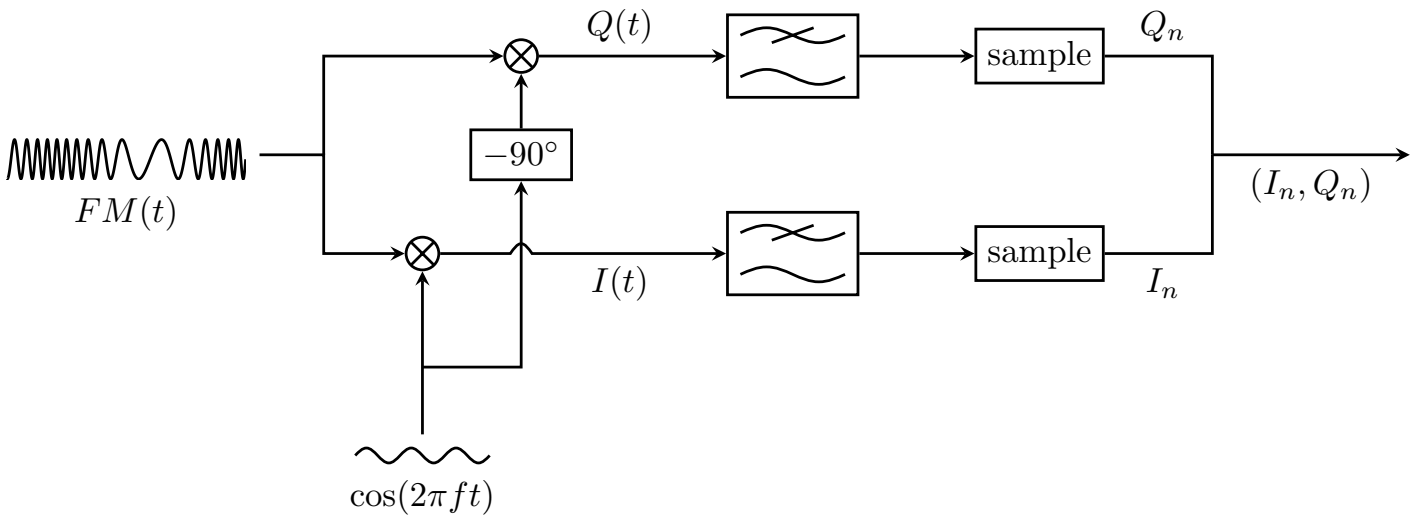
1.35 Insruction Execution




```
\tikzstyle{block} = [rectangle, draw, fill=blue!20,
    text width=5em, text centered, rounded corners, minimum height=4em]

\definecolor{mygreen}{rgb}{0,0.6,0}
\definecolor{echodrk}{HTML}{0099cc}

\begin{tikzpicture}[node distance=3cm, auto]
        \draw[opacity=0] (-6, -3.5) rectangle (4, 3.3);
        \begin{scope}[shift={(-4,-2)},transform canvas={scale=0.7}]
                \node [block, color=black, very thick, fill=lightgray!70, minimum height=15em, text width
                    =20em] (cpu) {};
                \node [above left] (lab) at (cpu.south east) {\LARGE \bf CPU};
                \node [below right=2.5em, block, color=black, very thick, fill=lightgray!30, minimum height
                    =2em, inner sep=0em, text width=2em] (PC) at (cpu.north west) {\tt 13};
                \node[below=0.1em of PC] (lPC) {\tt PC};
                \node [right=1em of PC, block, color=black, very thick, fill=lightgray!30, minimum height=2
                    em, inner sep=0em, text width=2em] (SP) {\tt 25};
                \node[below=0.1em of SP] (lSP) {\tt SP};
                \node [right=1em of SP, block, color=black, very thick, fill=lightgray!30, minimum height=2
                    em, inner sep=0em, text width=2em] (A) {\tt 1};
                \node[below=0.1em of A] (lA) {\tt A};
                \node [right=1em of A, block, color=black, very thick, fill=lightgray!30, minimum height=2
                    em, inner sep=0em, text width=2em] (B) {\tt 7};
                \node[below=0.1em of B] (lB) {\tt B};
                \node [right=1em of B, block, color=black, very thick, fill=lightgray!30, minimum height=2
                    em, inner sep=0em, text width=2em] (C) {\tt 3};
                \node[below=0.1em of C] (lC) {\tt C};
                \node [right=0.6em of C] (etc) {\Huge \dots};
                \node [below=1.5em of PC, block, color=black, very thick, fill=lightgray!30, minimum height
                    =2em, inner sep=0em, text width=2em] (ZF) {\tt F};
                \node[below=0.1em of ZF] (lZF) {\tt ZF};
                \node [right=1em of ZF, block, color=black, very thick, fill=lightgray!30, minimum height=2
                    em, inner sep=0em, text width=2em] (OF) {\tt T};
                \node[below=0.1em of OF] (lOF) {\tt OF};
                \node [right=1em of OF, block, color=black, very thick, fill=lightgray!30, minimum height=2
                    em, inner sep=0em, text width=2em] (HCF) {\tt F};
```

```
                \node[below=0.1em of HCF] (lHCF) {\tt HCF};
                \node [right=1em of HCF, block, color=black, very thick, fill=lightgray!30, minimum height
                    =2em, inner sep=0em, text width=2em] (CF) {\tt F};
                \node[below=0.1em of CF] (lCF) {\tt CF};
                \node [right=1em of CF, block, color=black, very thick, fill=lightgray!30, minimum height=2
                    em, inner sep=0em, text width=5em] (tkz) {\tt 15739};
                \node[below=0.1em of tkz] (ltkz) {\tt ticks};

                \coordinate (PC) at (-0.5, 2);
                \coordinate (A) at (1.1, 2);
                \coordinate (ZF) at (-0.5, 0.6);
                \coordinate (OF) at (0.3, 0.6);
                \coordinate (HCF) at (1.1, 0.6);
                \coordinate (CF) at (1.9, 0.6);
                \coordinate (tkz) at (3.4, 1.0);
        \end{scope}
        \begin{scope}[font=\ttfamily, array/.style={matrix of nodes,nodes={draw, minimum size=7mm, fill=
            green!30},column sep=-\pgflinewidth, row sep=0.5mm, nodes in empty cells, row 2/.style={nodes={
            draw=none, fill=none, minimum size=5mm}}}, shift={(-2.9,2)},transform canvas={scale=1.0}]
                \matrix[array,ampersand replacement=\&] (array) {
        6 \&  12 \&  1 \&  214 \&  5 \&  0 \&  255 \& 4  \\
        {\tiny \dots} \& 9 \& 10 \& 11 \& 12 \& 13 \& 14 \& {\tiny \dots}\\};

                \begin{scope}[on background layer]
                        \fill[green!10] (array-2-1.north west) rectangle (array-2-8.south east);
                \end{scope}
                \draw[<->, opacity=0.0]([yshift=0mm]array-1-1.north west) -- node[above,color=black,
                    opacity=1.0] {Memory} ([yshift=0mm]array-1-8.north east);

                \node[draw, fill=red, opacity=0.5, minimum size=6mm] at (array-1-5) (box) {};

                \draw (array-2-8.east)--++(0:3mm) node [right]{Address};

                \draw[-stealth, ultra thick, red] (PC) -- (array-2-5);
                \node[] (subi) at (6, -2) {\tt Sub(A, \textcolor{red}{5})};
                \draw[-stealth, ultra thick, mygreen] (box) -- (subi);
                \path[-stealth, ultra thick, echodrk] (subi.west) edge[bend right=20] (A);
                \path[-stealth, ultra thick, echodrk] (subi.west) edge[bend right=20] (PC);
                \draw[-stealth, ultra thick, echodrk] (subi) -- (tkz);
                \path[-stealth, ultra thick, echodrk] (subi) edge[bend left=65] (ZF);
                \path[-stealth, ultra thick, echodrk] (subi) edge[bend left=65] (OF);
                \path[-stealth, ultra thick, echodrk] (subi) edge[bend left=65] (HCF);
                \path[-stealth, ultra thick, echodrk] (subi) edge[bend left=65] (CF);
        \end{scope}
\end{tikzpicture}
```

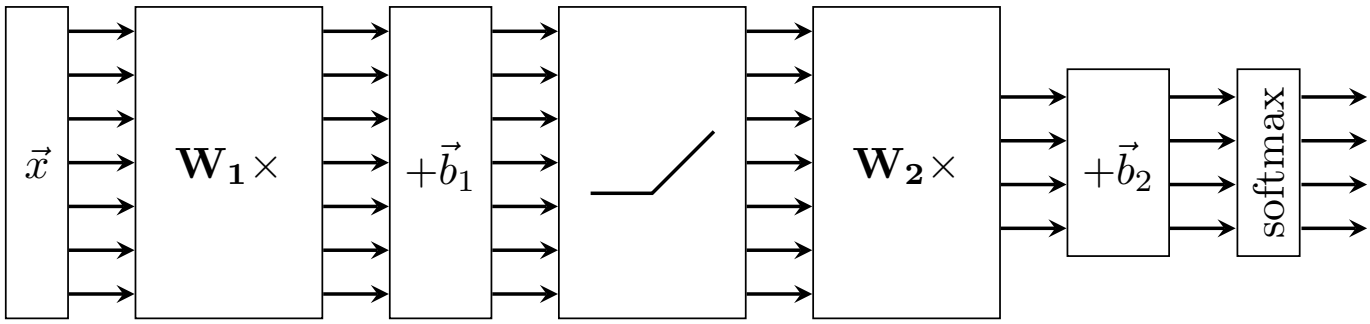
1.36 IQ Sampling




```
\begin{tikzpicture}[cross/.style={path picture={
        \draw[black] (path picture bounding box.south east) -- (path picture bounding box.north west) (path
             picture bounding box.south west) -- (path picture bounding box.north east);
        }}]
```

```
        \node[rectangle, align=center] (fm) at (-2, 0) {\begin{tikzpicture}[samples=1000, domain=0:5]
                        \begin{axis}[
                                hide axis,
                                width=4cm, height=2cm,
                                xtick=\empty,
                                ytick=\empty,
                                xlabel=\empty,
                                ylabel=\empty,
                                xmin=0, xmax=5,
                                ymin=-2.1, ymax=2.1,
                                trig format = rad
                        ]
                                \addplot expression [no markers, smooth, thick, black] {2*sin(2*pi*3*x - 8*
                                    cos(2*pi*0.25*x))};
                        \end{axis}
        \end{tikzpicture}\\ $FM(t)$};

        \node[rectangle, align=center] (cos) at (1, -3) {\tikz \draw[x=1.5ex, y=1ex, thick] (0, 0) sin
            (0.5, 0.5) cos (1, 0) sin (1.5, -0.5) cos (2, 0) sin (2.5, 0.5) cos (3, 0) sin (3.5, -0.5) cos
            (4, 0) sin (4.5, 0.5) cos (5, 0) sin (5.5, -0.5) cos (6, 0);\\ $\cos(2\pi f t)$};

        \node[circle, draw, cross, thick]  (mul1) at (1, -0.7) {};
        \node[circle, draw, cross, thick]  (mul2) at (2, 1.3) {};
        \node[rectangle, draw, thick] (rot) at (2, 0.3) {$-90^\circ$};
        \node[rectangle] (it) at (3, -1) {$I(t)$};
        \node[rectangle] (qt) at (3, 1.6) {$Q(t)$};
        \node[rectangle, draw, thick, align=center] (lp1) at (4.75, -0.7) {\tikz \draw[x=3.5ex, y=1ex,
            thick] (0, 0) sin (0.5, 0.5) cos (1, 0) sin (1.5, -0.5) cos (2, 0) (0.6, -0.5) -- (1.4, 0.5);\\
             \tikz \draw[x=3.5ex, y=1ex, thick] (0, 0) sin (0.5, 0.5) cos (1, 0) sin (1.5, -0.5) cos (2, 0)
            ;};
        \node[rectangle, draw, thick, align=center] (lp2) at (4.75, 1.3) {\tikz \draw[x=3.5ex, y=1ex, thick
            ] (0, 0) sin (0.5, 0.5) cos (1, 0) sin (1.5, -0.5) cos (2, 0) (0.6, -0.5) -- (1.4, 0.5);\\ \
            tikz \draw[x=3.5ex, y=1ex, thick] (0, 0) sin (0.5, 0.5) cos (1, 0) sin (1.5, -0.5) cos (2, 0)
            ;};
        \node[rectangle, draw, thick] (samp1) at (7.25, -0.7) {sample};
        \node[rectangle, draw, thick] (samp2) at (7.25, 1.3) {sample};
        \node[rectangle] (in) at (8.5, -1) {$I_n$};
        \node[rectangle] (qn) at (8.5, 1.6) {$Q_n$};

        \draw[thick, -stealth] (-0.65, 0.3) -- (0, 0.3) |- (mul1);
        \draw[thick, -stealth] (0, 0.3) |- (mul2);
        \draw[thick, -stealth] (cos) -- (mul1);
        \draw[thick, -stealth] (1, -1.85) -| (rot);
        \draw[thick, -stealth] (rot) -- (mul2);
        \draw[thick] (mul1) -- (1.9, -0.7);
        \draw[thick] (1.89, -0.7) sin (2, -0.6) cos (2.11, -0.7);
        \draw[thick, -stealth] (2.1, -0.7) -- (lp1);
        \draw[thick, -stealth] (mul2) -- (lp2);
        \draw[thick, -stealth] (lp1) -- (samp1);
        \draw[thick, -stealth] (lp2) -- (samp2);
        \draw[thick] (samp1) -| (9, 0.3);
        \draw[thick] (samp2) -| (9, 0.3);
        \draw[thick, -stealth] (9, 0.3) -- node[below] {$(I_n, Q_n)$} (11, 0.3);

\end{tikzpicture}
```

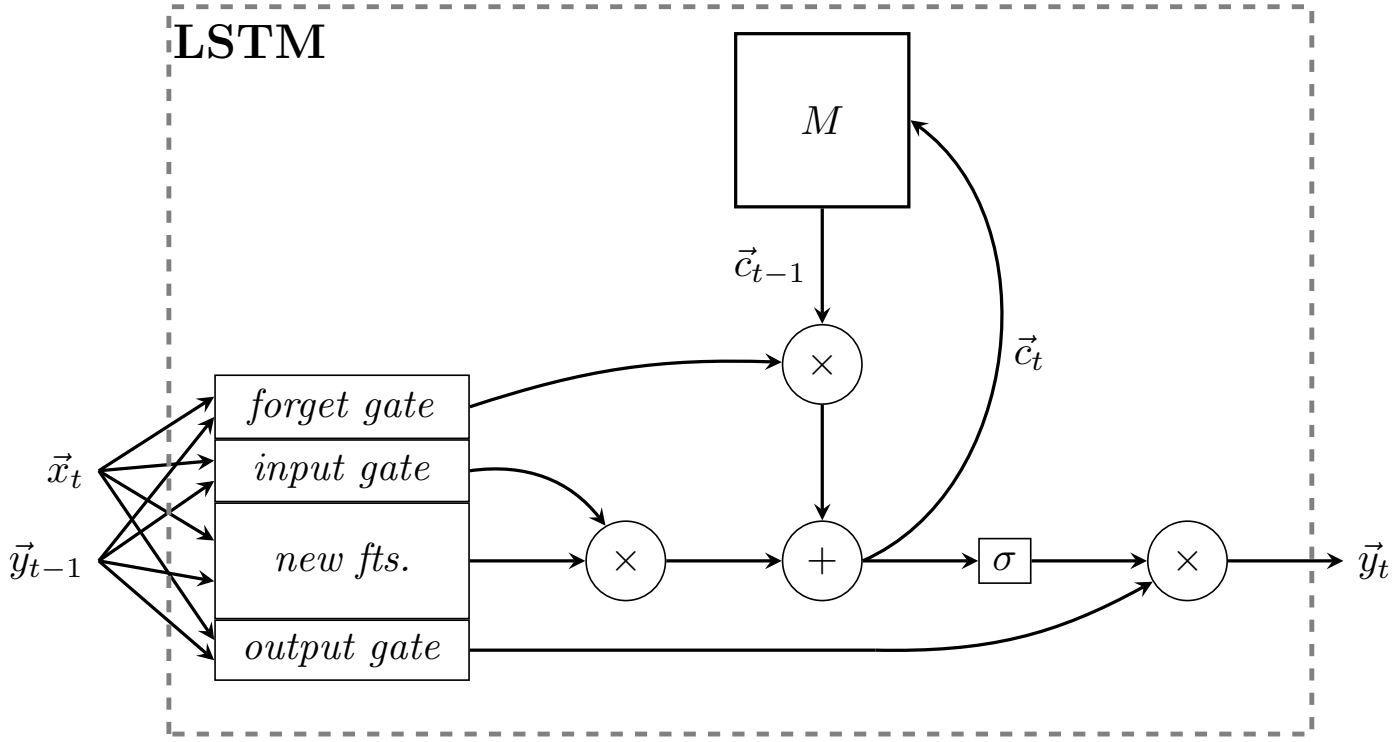
1.37 Lego Deep Learning




```
\tikzstyle{stateTransition}=[-stealth, thick]
```

```
\begin{tikzpicture}

        \node[rectangle, draw, minimum width=0.5cm,minimum height=2.5cm] (X) at (-2, 0) {$\vec{x}$};

        \node[rectangle, draw, right=1.5em of X, text depth=0em, minimum width=1.5cm,minimum height=2.5cm]
            (W1) {${\bf W_1}\times$};

        \node[rectangle, draw, right=1.5em of W1, text depth=0em, minimum width=0.5cm,minimum height=2.5cm]
             (B1) {$+ \vec{b}_1$};

        \node[rectangle, draw, right=1.5em of B1, text depth=0em, minimum width=1.5cm,minimum height=2.5cm]
             (RL) {
                \begin{tikzpicture}
                        \draw[thick] (0,0) -- (0.5, 0);
                        \draw[thick] (0.49,-0.004) -- (0.99, 0.496);
                \end{tikzpicture}
        };

        \node[rectangle, draw, right=1.5em of RL, text depth=0em, minimum width=1.5cm,minimum height=2.5cm]
             (W) {${\bf W_2}\times$};

        \node[rectangle, draw, right=1.5em of W, text depth=0em, minimum width=0.5cm,minimum height=1.5cm]
            (B) {$+ \vec{b}_2$};

        \node[right=1.5em of B, inner sep=0em] (out) {
        \begin{tikzpicture}
                \node[rectangle, draw, rotate=90, minimum height=0.5cm, minimum width=1.5cm] (out) {softmax
                    };
        \end{tikzpicture}
        };

        \node[right=1.5em of out] (outt) {};

        \foreach \x in {1,...,3}
                \draw[stateTransition] ([yshift=\x em]X.east) -- ([yshift=\x em]W1.west);
    \foreach \x in {1,...,3}
                \draw[stateTransition] ([yshift=-\x em]X.east) -- ([yshift=-\x em]W1.west);
        \draw[-stealth, thick] (X) -- (W1);

        \foreach \x in {1,...,3}
                \draw[stateTransition] ([yshift=\x em]W1.east) -- ([yshift=\x em]B1.west);
    \foreach \x in {1,...,3}
                \draw[stateTransition] ([yshift=-\x em]W1.east) -- ([yshift=-\x em]B1.west);
        \draw[-stealth, thick] (W1) -- (B1);

        \foreach \x in {1,...,3}
                \draw[stateTransition] ([yshift=\x em]B1.east) -- ([yshift=\x em]RL.west);
    \foreach \x in {1,...,3}
                \draw[stateTransition] ([yshift=-\x em]B1.east) -- ([yshift=-\x em]RL.west);
        \draw[-stealth, thick] (B1) -- (RL);

        \foreach \x in {1,...,3}
                \draw[stateTransition] ([yshift=\x em]RL.east) -- ([yshift=\x em]W.west);
    \foreach \x in {1,...,3}
                \draw[stateTransition] ([yshift=-\x em]RL.east) -- ([yshift=-\x em]W.west);
        \draw[-stealth, thick] (RL) -- (W);

        \foreach \x in {-1.5, -0.5, 0.5, 1.5}
                \draw[stateTransition] ([yshift=\x em]W.east) -- ([yshift=\x em]B.west);
        \foreach \x in {-1.5, -0.5, 0.5, 1.5}
                \draw[stateTransition] ([yshift=\x em]B.east) -- ([yshift=\x em]out.west);
        \foreach \x in {-1.5, -0.5, 0.5, 1.5}
                \draw[stateTransition] ([yshift=\x em]out.east) -- ([yshift=\x em]outt.west);

\end{tikzpicture}
```

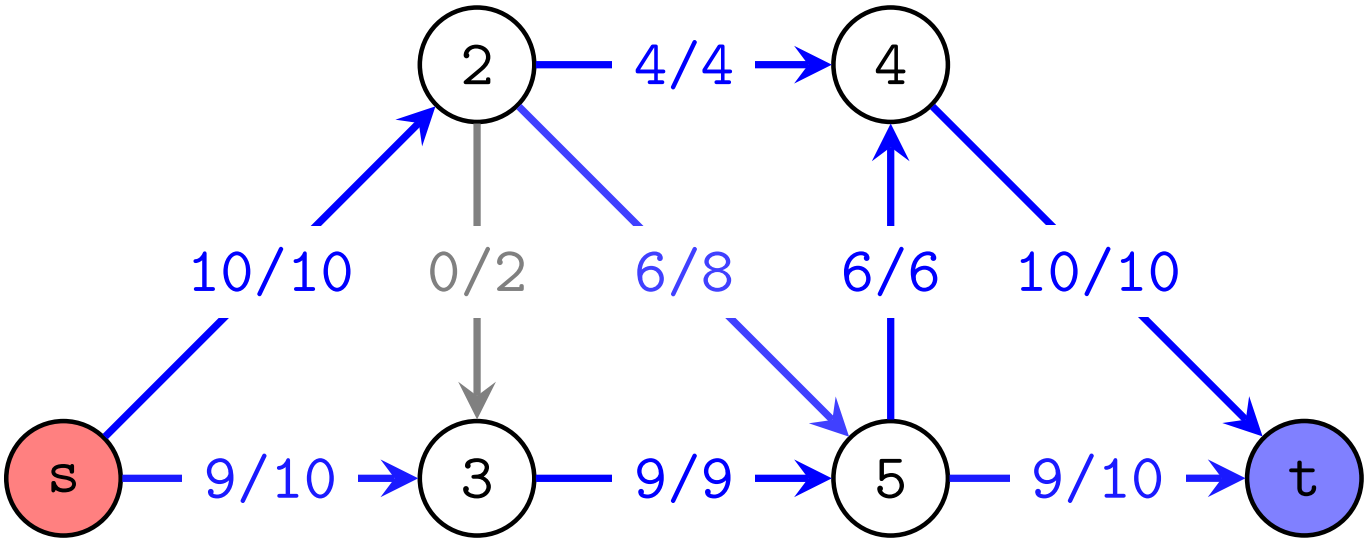
1.38 Long Short Term Memory




```
\begin{tikzpicture}

        \node[rectangle, draw, minimum width=2.2cm, minimum height=1cm] (FT) {\emph{new fts.}};
        \node[rectangle, above =0em of FT, draw, minimum width=2.2cm] (IG) {\emph{input gate}};
        \node[rectangle, above=0em of IG, draw, minimum width=2.2cm] (FG) {\emph{forget gate}};
        \node[rectangle, below=0em of FT, draw, minimum width=2.2cm] (OG) {\emph{output gate}};
        \node[left=of IG] (X) {$\vec{x}_t$};
        \node[left=of FT] (Y) {$\vec{y}_{t-1}$};

        \draw[-stealth, thick] (X.east) -- ([yshift=0.5em]FT.west);
        \draw[-stealth, thick] (X.east) -- ([yshift=0.25em]IG.west);
        \draw[-stealth, thick] (X.east) -- ([yshift=0.25em]FG.west);
        \draw[-stealth, thick] (X.east) -- ([yshift=0.25em]OG.west);
        \draw[-stealth, thick] (Y.east) -- ([yshift=-0.5em]FT.west);
        \draw[-stealth, thick] (Y.east) -- ([yshift=-0.25em]IG.west);
        \draw[-stealth, thick] (Y.east) -- ([yshift=-0.25em]FG.west);
        \draw[-stealth, thick] (Y.east) -- ([yshift=-0.25em]OG.west);

        \node[circle, draw, right=of FT] (t1) {$\times$};
        \node[circle, draw, right=of t1] (pl) {$+$};
        \node[rectangle, draw, right=of pl] (th) {$\sigma$};
        \node[circle, draw, right=of th] (t2) {$\times$};
        \node[right=of t2] (Y1) {$\vec{y}_t$};

        \node[circle, draw, above=of pl] (t3) {$\times$};

        \node[rectangle, thick, draw, above=of t3, minimum width=1.5cm, minimum height=1.5cm] (M) {$M$};

        \draw[-stealth, thick] (FT) -- (t1);
        \draw[-stealth, thick] (t1) -- (pl);
        \draw[-stealth, thick] (pl) -- (th);
        \draw[-stealth, thick] (th) -- (t2);
        \draw[-stealth, thick] (t2) -- (Y1);
        \draw[-stealth, thick] (M) -- node[left] {$\vec{c}_{t-1}$} (t3);
        \draw[-stealth, thick] (t3) -- (pl);
        \path[-stealth, thick] (IG.east) edge[bend left] (t1);
        \draw[thick] (OG.east) -- ([xshift=10em]OG.east);
        \path[-stealth, thick] (OG.east) -- ([xshift=10em]OG.east) edge[bend right=15] (t2);
        \path[-stealth, thick] (FG.east) edge[bend left=10] (t3);
        \path[-stealth, thick] (pl.east) edge[bend right=60] node[right] {$\vec{c}_t$} (M.east);

        \draw[-stealth, very thick, dashed, gray] (-1.5, -1.5) rectangle (8.4, 4.8);
        \node[] (tttxt) at (-0.8, 4.5) {\large \bf LSTM};
```

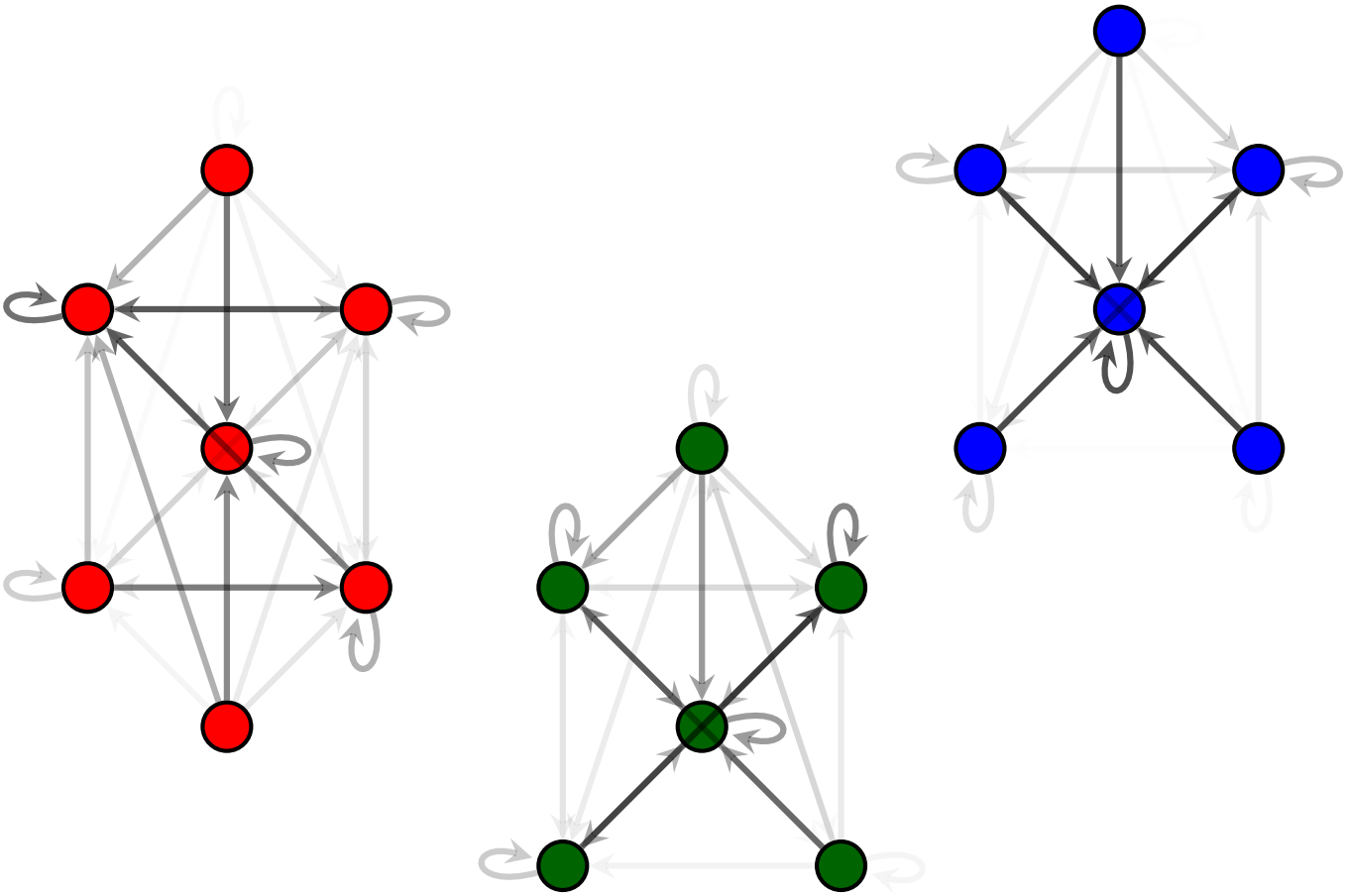
```
\end{tikzpicture}
```

1.39 Maximum Flow Problem




```
\begin{tikzpicture}[scale=0.8,every node/.style={scale=0.7},font=\tt]
        \SetUpEdge[lw         = 0.75pt,
                   color      = red,
                   labelcolor = white]
        \GraphInit[vstyle=Normal]
        \SetGraphUnit{2}
        \tikzset{VertexStyle/.append  style={fill=red!50}}
        \Vertex{s}
        \tikzset{VertexStyle/.append  style={fill=white}}
        \NOEA(s){2}
        \EA(2){4}
        \tikzset{VertexStyle/.append  style={fill=blue!50}}
        \SOEA(4){t}
        \tikzset{VertexStyle/.append  style={fill=white}}
        \EA(s){3}
        \EA(3){5}
        \SetUpEdge[labeltext=blue]
        \tikzset{EdgeStyle/.style={-stealth, color=blue}}
        \Edge[label=10/10](s)(2)
        \SetUpEdge[labeltext=blue!90]
        \tikzset{EdgeStyle/.style={-stealth, color=blue!90}}
        \Edge[label=9/10](s)(3)
        \SetUpEdge[labeltext=gray]
        \tikzset{EdgeStyle/.style={-stealth, color=gray}}
        \Edge[label=0/2](2)(3)
        \SetUpEdge[labeltext=blue]
        \tikzset{EdgeStyle/.style={-stealth, color=blue}}
        \Edge[label=4/4](2)(4)
        \SetUpEdge[labeltext=blue!75]
        \tikzset{EdgeStyle/.style={-stealth, color=blue!75}}
        \Edge[label=6/8](2)(5)
        \SetUpEdge[labeltext=blue]
        \tikzset{EdgeStyle/.style={-stealth, color=blue}}
        \Edge[label=9/9](3)(5)
        \SetUpEdge[labeltext=blue]
        \tikzset{EdgeStyle/.style={-stealth, color=blue}}
        \Edge[label=10/10](4)(t)
        \SetUpEdge[labeltext=blue]
        \tikzset{EdgeStyle/.style={-stealth, color=blue}}
        \Edge[label=6/6](5)(4)
        \SetUpEdge[labeltext=blue!90]
        \tikzset{EdgeStyle/.style={-stealth, color=blue!90}}
        \Edge[label=9/10](5)(t)
\end{tikzpicture}
```

1.40 MCL

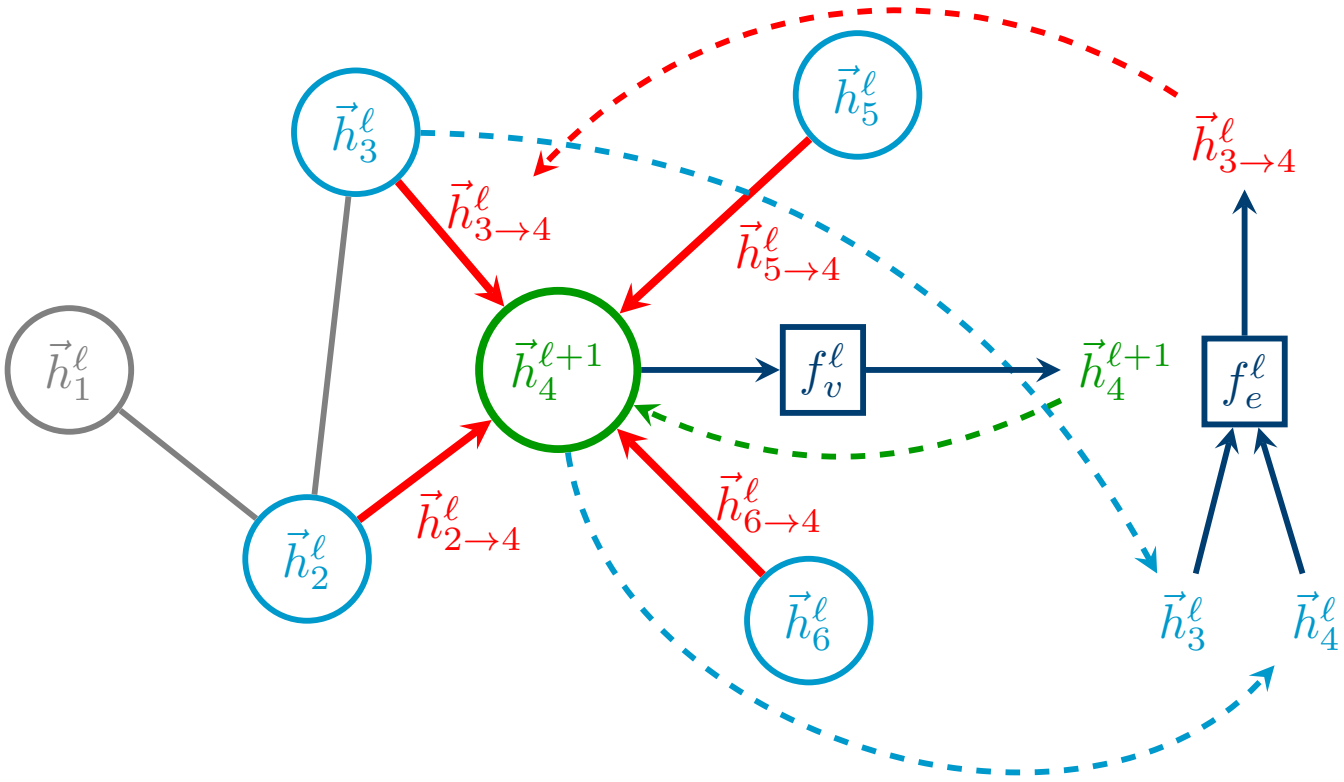


```
\definecolor{mygreen}{HTML}{006400}

\begin{tikzpicture}[node distance=2.8em]
                        \node[circle, thick, fill=red, draw] (0) {};
                        \node[circle, thick, below left=of 0, fill=red, draw] (1) {};
                        \node[circle, thick, below right=of 0, fill=red, draw] (2) {};
                        \node[circle, thick, below right=of 1, fill=red, draw] (3) {};
                        \node[circle, thick, below left=of 3, fill=red, draw] (4) {};
                        \node[circle, thick, below right=of 3, fill=red, draw] (5) {};
                        \node[circle, thick, below right=of 4, fill=red, draw] (6) {};
                        \node[circle, thick, right=of 5, fill=mygreen, draw] (7) {};
                        \node[circle, thick, above right=of 7, fill=mygreen, draw] (8) {};
                        \node[circle, thick, below right=of 8, fill=mygreen, draw] (9) {};
                        \node[circle, thick, below right=of 7, fill=mygreen, draw] (10) {};
                        \node[circle, thick, below left=of 10, fill=mygreen, draw] (11) {};
                        \node[circle, thick, below right=of 10, fill=mygreen, draw] (12) {};
                        \node[circle, thick, above right=of 9, fill=blue, draw] (13) {};
                        \node[circle, thick, above right=of 13, fill=blue, draw] (16) {};
                        \node[circle, thick, above left=of 16, fill=blue, draw] (14) {};
                        \node[circle, thick, above right=of 14, fill=blue, draw] (15) {};
                        \node[circle, thick, above right=of 16, fill=blue, draw] (17) {};
                        \node[circle, thick, below right=of 16, fill=blue, draw] (18) {};

\path[-stealth, very thick] (0) edge [->, >=stealth, opacity=0.02, loop above] (0);
\draw[very thick, opacity=0.30, -stealth] (0) -- (1);
\draw[very thick, opacity=0.07, -stealth] (0) -- (2);
\draw[very thick, opacity=0.53, -stealth] (0) -- (3);
\draw[very thick, opacity=0.02, -stealth] (0) -- (4);
\draw[very thick, opacity=0.05, -stealth] (0) -- (5);

\path[-stealth, very thick] (1) edge [->, >=stealth, opacity=0.56, loop left] (1);
\draw[very thick, opacity=0.25, -stealth] (1) -- (2);
\draw[very thick, opacity=0.11, -stealth] (1) -- (3);
\draw[very thick, opacity=0.02, -stealth] (1) -- (4);
\draw[very thick, opacity=0.05, -stealth] (1) -- (5);

\draw[very thick, opacity=0.54, -stealth] (2) -- (1);
```

```
\path[-stealth, very thick] (2) edge [->, >=stealth, opacity=0.31, loop right] (2);
\draw[very thick, opacity=0.04, -stealth] (2) -- (3);
\draw[very thick, opacity=0.03, -stealth] (2) -- (4);
\draw[very thick, opacity=0.07, -stealth] (2) -- (5);

\draw[very thick, opacity=0.35, -stealth] (3) -- (1);
\draw[very thick, opacity=0.09, -stealth] (3) -- (2);
\path[-stealth, very thick] (3) edge [->, >=stealth, opacity=0.44, loop right] (3);
\draw[very thick, opacity=0.03, -stealth] (3) -- (4);
\draw[very thick, opacity=0.08, -stealth] (3) -- (5);

\draw[very thick, opacity=0.22, -stealth] (4) -- (1);
\draw[very thick, opacity=0.07, -stealth] (4) -- (2);
\draw[very thick, opacity=0.05, -stealth] (4) -- (3);
\path[-stealth, very thick] (4) edge [->, >=stealth, opacity=0.19, loop left] (4);
\draw[very thick, opacity=0.46, -stealth] (4) -- (5);

\draw[very thick, opacity=0.38, -stealth] (5) -- (1);
\draw[very thick, opacity=0.09, -stealth] (5) -- (2);
\draw[very thick, opacity=0.12, -stealth] (5) -- (3);
\draw[very thick, opacity=0.10, -stealth] (5) -- (4);
\path[-stealth, very thick] (5) edge [->, >=stealth, opacity=0.31, loop below] (5);

\draw[very thick, opacity=0.31, -stealth] (6) -- (1);
\draw[very thick, opacity=0.08, -stealth] (6) -- (2);
\draw[very thick, opacity=0.46, -stealth] (6) -- (3);
\draw[very thick, opacity=0.04, -stealth] (6) -- (4);
\draw[very thick, opacity=0.10, -stealth] (6) -- (5);

\path[-stealth, very thick] (7) edge [->, >=stealth, opacity=0.32, loop above] (7);
\draw[very thick, opacity=0.10, -stealth] (7) -- (8);
\draw[very thick, opacity=0.12, -stealth] (7) -- (9);
\draw[very thick, opacity=0.36, -stealth] (7) -- (10);
\draw[very thick, opacity=0.07, -stealth] (7) -- (11);
\draw[very thick, opacity=0.03, -stealth] (7) -- (12);

\draw[very thick, opacity=0.28, -stealth] (8) -- (7);
\path[-stealth, very thick] (8) edge [->, >=stealth, opacity=0.11, loop above] (8);
\draw[very thick, opacity=0.13, -stealth] (8) -- (9);
\draw[very thick, opacity=0.37, -stealth] (8) -- (10);
\draw[very thick, opacity=0.07, -stealth] (8) -- (11);
\draw[very thick, opacity=0.03, -stealth] (8) -- (12);

\draw[very thick, opacity=0.03, -stealth] (9) -- (7);
\draw[very thick, opacity=0.01, -stealth] (9) -- (8);
\path[-stealth, very thick] (9) edge [->, >=stealth, opacity=0.48, loop above] (9);
\draw[very thick, opacity=0.27, -stealth] (9) -- (10);
\draw[very thick, opacity=0.21, -stealth] (9) -- (11);

\draw[very thick, opacity=0.10, -stealth] (10) -- (7);
\draw[very thick, opacity=0.04, -stealth] (10) -- (8);
\draw[very thick, opacity=0.31, -stealth] (10) -- (9);
\path[-stealth, very thick] (10) edge [->, >=stealth, opacity=0.39, loop right] (10);
\draw[very thick, opacity=0.15, -stealth] (10) -- (11);

\draw[very thick, opacity=0.04, -stealth] (11) -- (7);
\draw[very thick, opacity=0.01, -stealth] (11) -- (8);
\draw[very thick, opacity=0.45, -stealth] (11) -- (9);
\draw[very thick, opacity=0.29, -stealth] (11) -- (10);
\path[-stealth, very thick] (11) edge [->, >=stealth, opacity=0.20, loop left] (11);

\draw[very thick, opacity=0.36, -stealth] (12) -- (7);
\draw[very thick, opacity=0.13, -stealth] (12) -- (8);
\draw[very thick, opacity=0.08, -stealth] (12) -- (9);
\draw[very thick, opacity=0.34, -stealth] (12) -- (10);
\draw[very thick, opacity=0.05, -stealth] (12) -- (11);
\path[-stealth, very thick] (12) edge [->, >=stealth, opacity=0.04, loop right] (12);

\path[-stealth, very thick] (13) edge [->, >=stealth, opacity=0.12, loop below] (13);
\draw[very thick, opacity=0.03, -stealth] (13) -- (14);
\draw[very thick, opacity=0.52, -stealth] (13) -- (16);
\draw[very thick, opacity=0.32, -stealth] (13) -- (17);

\draw[very thick, opacity=0.01, -stealth] (14) -- (13);
\path[-stealth, very thick] (14) edge [->, >=stealth, opacity=0.19, loop left] (14);
\draw[very thick, opacity=0.65, -stealth] (14) -- (16);
```

```
\draw[very thick, opacity=0.11, -stealth] (14) -- (17);
\draw[very thick, opacity=0.02, -stealth] (14) -- (18);

\draw[very thick, opacity=0.04, -stealth] (15) -- (13);
\draw[very thick, opacity=0.13, -stealth] (15) -- (14);
\path[-stealth, very thick] (15) edge [->, >=stealth, opacity=0.01, loop right] (15);
\draw[very thick, opacity=0.62, -stealth] (15) -- (16);
\draw[very thick, opacity=0.18, -stealth] (15) -- (17);
\draw[very thick, opacity=0.01, -stealth] (15) -- (18);

\draw[very thick, opacity=0.03, -stealth] (16) -- (13);
\draw[very thick, opacity=0.09, -stealth] (16) -- (14);
\path[-stealth, very thick] (16) edge [->, >=stealth, opacity=0.69, loop below] (16);
\draw[very thick, opacity=0.18, -stealth] (16) -- (17);

\draw[very thick, opacity=0.07, -stealth] (17) -- (13);
\draw[very thick, opacity=0.05, -stealth] (17) -- (14);
\draw[very thick, opacity=0.61, -stealth] (17) -- (16);
\path[-stealth, very thick] (17) edge [->, >=stealth, opacity=0.26, loop right] (17);

\draw[very thick, opacity=0.01, -stealth] (18) -- (13);
\draw[very thick, opacity=0.25, -stealth] (18) -- (14);
\draw[very thick, opacity=0.01, -stealth] (18) -- (15);
\draw[very thick, opacity=0.61, -stealth] (18) -- (16);
\draw[very thick, opacity=0.09, -stealth] (18) -- (17);
\path[-stealth, very thick] (18) edge [->, >=stealth, opacity=0.03, loop below] (18);

\end{tikzpicture}
```

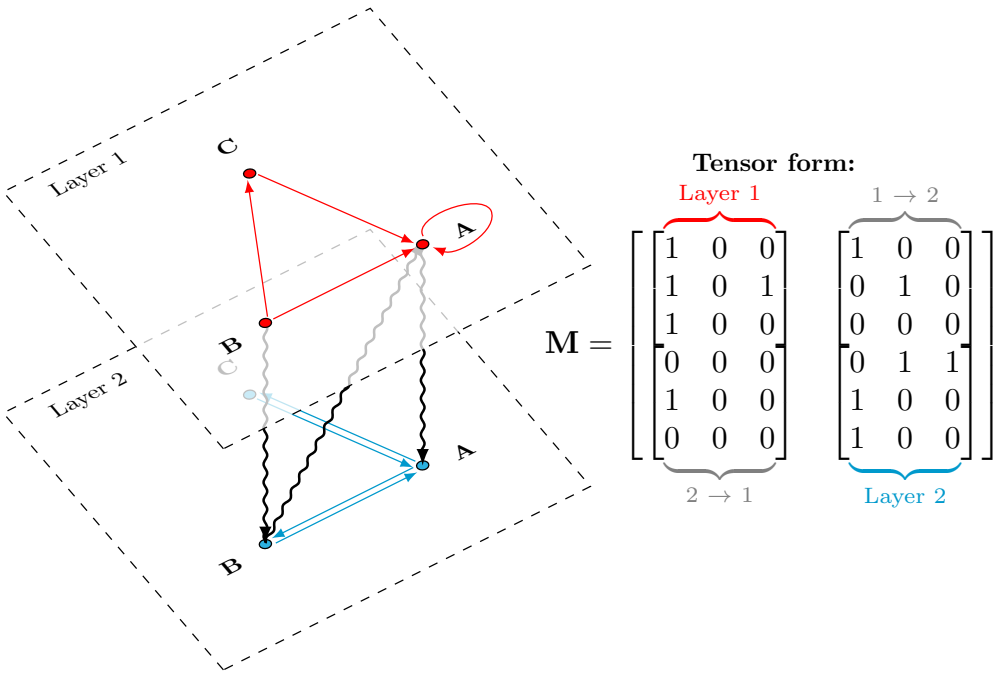
1.41 Message Passing Neural Network




```
\definecolor{echodrk}{HTML}{0099cc}
\definecolor{olivegreen}{rgb}{0,0.6,0}
\definecolor{camdrk}{RGB}{0,62,114}

\begin{tikzpicture}
```

```
        \node[circle, gray, draw, very thick] (1) {$\vec{h}^\ell_1$};
        \node[circle, echodrk, draw, below right=2em and 3em of 1, very thick] (2) {$\vec{h}^\ell_2$};
        \node[circle, draw, echodrk, above right=3em and 4em of 1, very thick] (3) {$\vec{h}^\ell_3$};
        \node[circle, draw, olivegreen, right=7em of 1, ultra thick] (4) {$\vec{h}^{\ell+1}_4$};
        \node[circle, echodrk, draw, above right=3.5em and 4em of 4, very thick] (5) {$\vec{h}^\ell_5$};
        \node[circle, echodrk, draw, below right=3em and 3em of 4, very thick] (6) {$\vec{h}^\ell_6$};

        \draw[gray, very thick] (1) -- (2);
        \draw[gray, very thick] (2) -- (3);
        \draw[red, ultra thick, -stealth] (2) -- node[below, xshift=0.9em] (l1) {$\vec{h}_{2\rightarrow
            4}^\ell$} (4);
        \draw[red, ultra thick, -stealth] (3) -- node[above,xshift=1em, inner sep=0em] (l1) {$\vec{h}_{3\
            rightarrow 4}^\ell$} (4);
        \draw[red,ultra thick, -stealth] (5) -- node[right, yshift=-0.5em] (lr) {$\vec{h}_{5\rightarrow
            4}^\ell$} (4);
        \draw[red,ultra thick, -stealth] (6) -- node[right, xshift=0.1em] (lw) {$\vec{h}_{6\rightarrow 4}^\
            ell$} (4);

        \node[right=5.5em of 6, echodrk] (31) {$\vec{h}^\ell_3$};
        \node[right=1em of 31, echodrk] (41) {$\vec{h}^\ell_4$};

        \node[rectangle, draw, camdrk, very thick, above right=3em and -0.5em of 31] (F) {$f_e^\ell$};

        \node[above=3em of F, red] (34) {$\vec{h}^\ell_{3\rightarrow 4}$};

        \draw[very thick, camdrk, -stealth] (31) -- (F);
        \draw[very thick, camdrk, -stealth] (41) -- (F);
        \draw[very thick, camdrk, -stealth] (F) -- (34);

        \draw[very thick, -stealth, dashed, echodrk] (3) edge[bend left=30] (31);
        \draw[very thick, -stealth, dashed, echodrk] (4) edge[bend right=65] (41);
        \draw[very thick, -stealth, dashed, red] (34) edge[bend right=40] (l1);

        \node[right= of 4, camdrk, rectangle, draw, very thick] (G) {$f_v^\ell$};
        \node[right=4 em of G, olivegreen] (l11) {$\vec{h}^{\ell+1}_4$};

        \draw[-stealth, camdrk, very thick] (4) -- (G);
        \draw[-stealth, camdrk, very thick] (G) -- (l11);

        \draw[very thick, -stealth, dashed, olivegreen] (l11) edge[bend left=25] (4);
\end{tikzpicture}
```

1.42 Multilayer Network

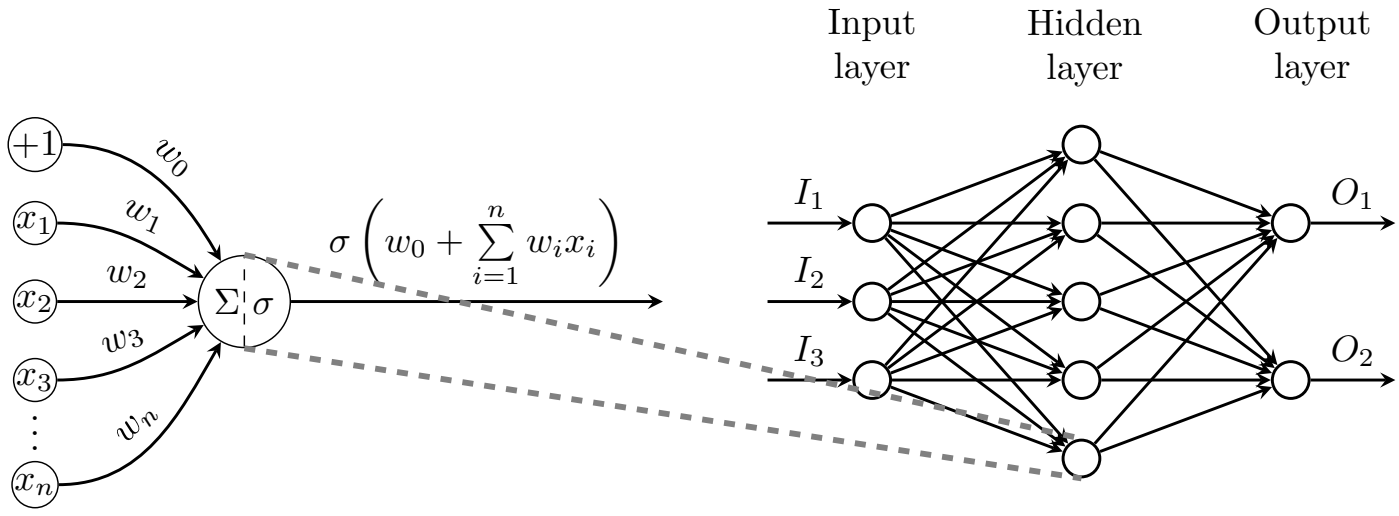



```
\definecolor{echoreg}{HTML}{2cb1e1}
```

```
\definecolor{echodrk}{HTML}{0099cc}

\tikzstyle{mybox} = [text=black, very thick,
    rectangle, rounded corners, inner sep=10pt, inner ysep=20pt]
\tikzstyle{fancytitle} =[text=black]

\newcommand{\yslant}{0.5}
\newcommand{\xslant}{-0.6}

\newcommand\overmat[3]{%
  \makebox[0pt][l]{$\smash{\color{#3}\overbrace{\phantom{%
    \begin{matrix}#2\end{matrix}}}^{\text{#1}}}$}#2}
\newcommand\undermat[3]{%
  \makebox[0pt][l]{$\smash{\color{#3}\underbrace{\phantom{%
    \begin{matrix}#2\end{matrix}}}_{\text{#1}}}$}#2}
\newcommand\partialphantom{\vphantom{\frac{\partial e_{P,M}}{\partial w_{1,1}}}}

\begin{tikzpicture}[scale=0.58,every node/.style={minimum size=1cm},on grid]

        \node [mybox, scale=1.0] at (10.5, 2) (box){%
                \begin{minipage}{0.6\textwidth}
                        \[  {\mathbf M} = {\left[
                        \begin{matrix}
                                \left[\overmat{\textcolor{red}Layer 1}{
                                \begin{matrix}
                                        1 & 0 & 0\\
                                        1 & 0 & 1\\
                                        1 & 0 & 0\\
                                \end{matrix}}{red}\right] & \left[\overmat{1 $\rightarrow$ 2}{
                                \begin{matrix}
                                        1 & 0 & 0\\
                                        0 & 1 & 0\\
                                        0 & 0 & 0\\
                                \end{matrix}}{gray}\right]\\
                                \left[\undermat{2 $\rightarrow$ 1}{
                                \begin{matrix}
                                        0 & 0 & 0\\
                                        1 & 0 & 0\\
                                        0 & 0 & 0\\
                                \end{matrix}}{gray}\right] & \left[\undermat{\textcolor{echodrk}Layer 2}{
                                \begin{matrix}
                                        0 & 1 & 1\\
                                        1 & 0 & 0\\
                                        1 & 0 & 0\\
                                \end{matrix}}{echodrk}\right]\\
                        \end{matrix}\right]}\]
        \end{minipage}
        };

        \node[fancytitle, scale=0.8] at (box.north) {\bf Tensor form:};

        % Layer 2
        \begin{scope}[
                yshift=-120,
                every node/.append style={yslant=\yslant,xslant=\xslant},
                yslant=\yslant,xslant=\xslant
        ]
                \draw[black, dashed, thin] (0,0) rectangle (7,7);

                \draw[fill=echoreg]
                        (5,2) node(111){} circle (.1)
                        (2,2) circle (.1)
                        (3.5,5) circle (.1);

                \draw[-latex, thin, color=echodrk]
                        (3.55,4.85) to (4.85,2.05);
                \draw[-latex, thin, color=echodrk]
                        (4.95,2.15) to (3.65,4.95);
                \draw[-latex, thin, color=echodrk]
                        (2.15,1.92) to (4.85,1.92);
                \draw[-latex, thin, color=echodrk]
                        (4.85,2.05) to (2.15,2.05);
                \fill[black]
                        (0.5,6.5) node[right, scale=.7] {Layer 2}
                        (5.1,1.9) node[right,scale=.7]{\bf A}
                        (1.9,1.9) node[left,scale=.7]{\bf B}
```

```
                        (3.5,5.1) node[above,scale=.7]{\bf C};
        \end{scope}

        % Interlayer crossconnections
        \draw[thick, -latex, decoration={snake, segment length=2mm, amplitude=0.2mm}, decorate] (3.8, 4) to
             (3.8, -0.32);
        \draw[thick, -latex, decoration={snake, segment length=2mm, amplitude=0.2mm}, decorate] (.8,2.4) to
             (.8,-1.8);
        \draw[thick, -latex, decoration={snake, segment length=2mm, amplitude=0.2mm}, decorate] (.8, -1.8)
            to (3.81, 4);

        % Layer 1
        \begin{scope}[
                yshift=0,
                every node/.append style={yslant=\yslant,xslant=\xslant},
                yslant=\yslant,xslant=\xslant
        ]
                \fill[white,fill opacity=.75] (0,0) rectangle (7,7);
                \draw[black, dashed, thin] (0,0) rectangle (7,7);

                \draw [fill=red]
                        (5,2) node(111){} circle (.1)
                        (2,2) circle (.1)
                        (3.5,5) circle (.1);

                \draw[-latex, thin, color=red]
                        (3.6,4.9) to (4.9,2.1);
                \draw[-latex, thin, color=red]
                        (2.15,2) to (4.85,2);
                \draw[-latex, thin, color=red]
                        (2.1,2.1) to (3.4,4.9);
                \draw[-latex, thin, color=red]
                        (5.1,2.15) to[bend left=90] (6.3, 2) to[bend left=70] (5.1, 1.85);

                \fill[black]
                        (0.5,6.5) node[right, scale=.7] {Layer 1}
                        (5.1,1.9) node[right,scale=.7]{\bf A}
                        (1.9,1.9) node[left,scale=.7]{\bf B}
                        (3.5,5.1) node[above,scale=.7]{\bf C};
        \end{scope}
\end{tikzpicture}
```

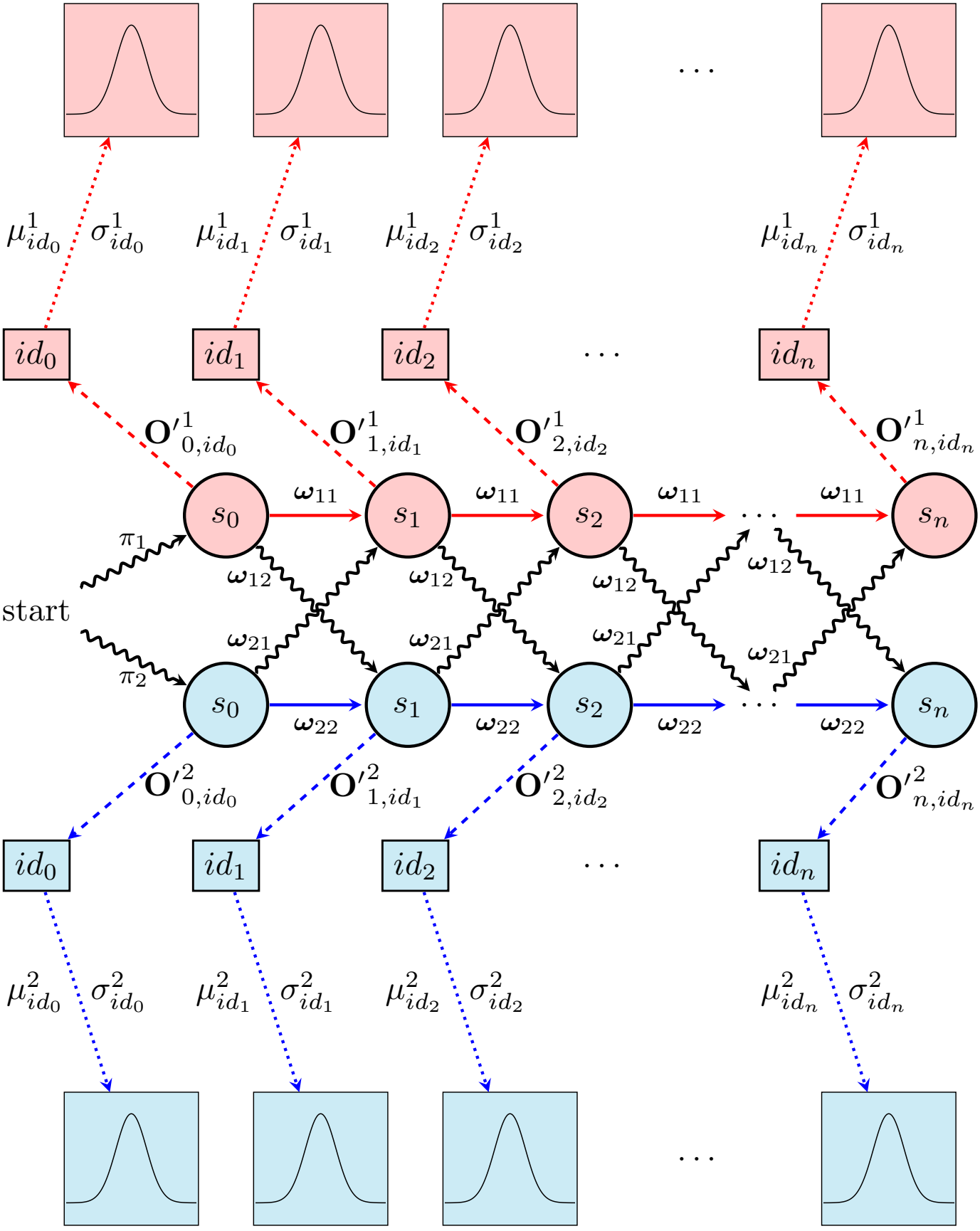
1.43 Multilayer Perceptron




```
\tikzstyle{inputNode}=[draw,circle,minimum size=10pt,inner sep=0pt]
\tikzstyle{stateTransition}=[-stealth, thick]

\begin{tikzpicture}
        \node[draw,circle,minimum size=25pt,inner sep=0pt] (x) at (0,0) {$\Sigma$ $\sigma$};

        \node[inputNode] (x0) at (-2, 1.5) {$\tiny +1$};
        \node[inputNode] (x1) at (-2, 0.75) {$\tiny x_1$};
```

```
        \node[inputNode] (x2) at (-2, 0) {$\tiny x_2$};
        \node[inputNode] (x3) at (-2, -0.75) {$\tiny x_3$};
        \node[inputNode] (xn) at (-2, -1.75) {$\tiny x_n$};

        \draw[stateTransition] (x0) to[out=0,in=120] node [midway, sloped, above] {$w_0$} (x);
        \draw[stateTransition] (x1) to[out=0,in=150] node [midway, sloped, above] {$w_1$} (x);
        \draw[stateTransition] (x2) to[out=0,in=180] node [midway, sloped, above] {$w_2$} (x);
        \draw[stateTransition] (x3) to[out=0,in=210] node [midway, sloped, above] {$w_3$} (x);
        \draw[stateTransition] (xn) to[out=0,in=240] node [midway, sloped, above] {$w_n$} (x);
        \draw[stateTransition] (x) -- (4,0) node [midway,above] {$\sigma\left(w_0 + \sum\limits_{i=1}^{n}{w
            _ix_i}\right)$};
        \draw[dashed] (0,-0.43) -- (0,0.43);
        \node (dots) at (-2, -1.15) {$\vdots$};
        \node[inputNode, thick] (i1) at (6, 0.75) {};
        \node[inputNode, thick] (i2) at (6, 0) {};
        \node[inputNode, thick] (i3) at (6, -0.75) {};

        \node[inputNode, thick] (h1) at (8, 1.5) {};
        \node[inputNode, thick] (h2) at (8, 0.75) {};
        \node[inputNode, thick] (h3) at (8, 0) {};
        \node[inputNode, thick] (h4) at (8, -0.75) {};
        \node[inputNode, thick] (h5) at (8, -1.5) {};

        \node[inputNode, thick] (o1) at (10, 0.75) {};
        \node[inputNode, thick] (o2) at (10, -0.75) {};

        \draw[stateTransition] (5, 0.75) -- node[above] {$I_1$} (i1);
        \draw[stateTransition] (5, 0) -- node[above] {$I_2$} (i2);
        \draw[stateTransition] (5, -0.75) -- node[above] {$I_3$} (i3);

        \draw[stateTransition] (i1) -- (h1);
        \draw[stateTransition] (i1) -- (h2);
        \draw[stateTransition] (i1) -- (h3);
        \draw[stateTransition] (i1) -- (h4);
        \draw[stateTransition] (i1) -- (h5);
        \draw[stateTransition] (i2) -- (h1);
        \draw[stateTransition] (i2) -- (h2);
        \draw[stateTransition] (i2) -- (h3);
        \draw[stateTransition] (i2) -- (h4);
        \draw[stateTransition] (i2) -- (h5);
        \draw[stateTransition] (i3) -- (h1);
        \draw[stateTransition] (i3) -- (h2);
        \draw[stateTransition] (i3) -- (h3);
        \draw[stateTransition] (i3) -- (h4);
        \draw[stateTransition] (i3) -- (h5);

        \draw[stateTransition] (h1) -- (o1);
        \draw[stateTransition] (h1) -- (o2);
        \draw[stateTransition] (h2) -- (o1);
        \draw[stateTransition] (h2) -- (o2);
        \draw[stateTransition] (h3) -- (o1);
        \draw[stateTransition] (h3) -- (o2);
        \draw[stateTransition] (h4) -- (o1);
        \draw[stateTransition] (h4) -- (o2);
        \draw[stateTransition] (h5) -- (o1);
        \draw[stateTransition] (h5) -- (o2);

        \node[above=of i1, align=center] (l1) {Input \\ layer};
        \node[right=2.3em of l1, align=center] (l2) {Hidden \\ layer};
        \node[right=2.3em of l2, align=center] (l3) {Output \\ layer};

        \draw[stateTransition] (o1) -- node[above] {$O_1$} (11, 0.75);
        \draw[stateTransition] (o2) -- node[above] {$O_2$} (11, -0.75);

        \path[dashed, double, ultra thick, gray] (x.north) edge[bend left=0] (h5.north);
        \path[dashed, double, ultra thick, gray] (x.south) edge[bend right=0] (h5.south);
\end{tikzpicture}
```

1.44 Multiplex Chain Gmhmm



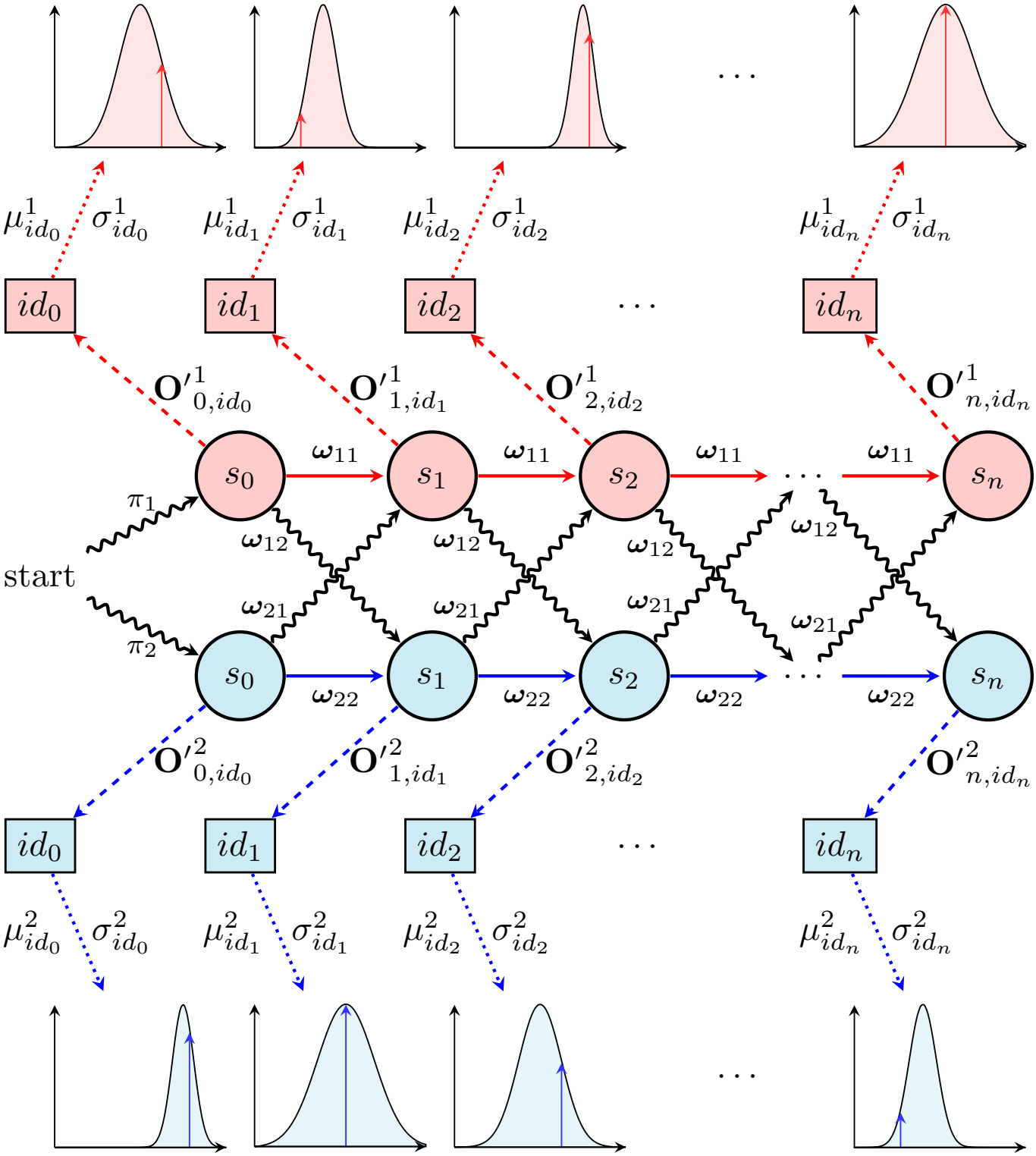

```
\definecolor{echodrk}{HTML}{0099cc}

\begin{tikzpicture} [scale=1.3, every node/.style={transform shape},start chain=1 going right, start chain
    =2 going right]
```

```
\node[state, fill=red!20, on chain=1, very thick, text depth=0pt] (1) {$s_0$};
\node[state, fill=red!20, on chain=1, very thick, text depth=0pt] (2) {$s_1$};
\node[state, fill=red!20, on chain=1, very thick, text depth=0pt] (3) {$s_2$};
\node[on chain=1] (md) {\dots};
\node[state, fill=red!20, on chain=1, very thick, text depth=0pt] (n) {$s_n$};
\draw[>=stealth, color=red, text=black, very thick, auto=right,loop above/.style={out=75,in=105,
    loop}, every loop]
        (1) edge node[above] {\footnotesize$\boldsymbol \omega_{11}$} (2)
        (2) edge node[above] {\footnotesize$\boldsymbol \omega_{11}$} (3)
        (3) edge node[above] {\footnotesize$\boldsymbol \omega_{11}$} (md)
        (md) edge node[above] {\footnotesize$\boldsymbol \omega_{11}$} (n);

\node[rectangle, thick, fill=red!20, draw] at (-2, 1.7) (y1) {$id_0$};
\node[rectangle, thick, fill=red!20, draw] at (0, 1.7) (y2) {$id_1$};
\node[rectangle, thick, fill=red!20, draw] at (2, 1.7) (y3) {$id_2$};
\node at (4, 1.7) (ymd) {\dots};
\node[rectangle, thick, fill=red!20, draw] at (6, 1.7) (yn) {$id_n$};

\draw[-stealth, color=red, text=black, very thick, dashed]
        (1) edge node[right] {${\bf O'}_{0,id_0}^1$} (y1)
        (2) edge node[right] {${\bf O'}_{1,id_1}^1$} (y2)
        (3) edge node[right] {${\bf O'}_{2,id_2}^1$} (y3)
        (n) edge node[right] {${\bf O'}_{n,id_n}^1$} (yn);

\node[rectangle, fill=red!20, draw, scale=0.2, minimum size=20em,above = 2cm of y1] at (-1, 2) (
    gauss1) {
        \begin{tikzpicture}
                \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                        \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                \end{axis}
        \end{tikzpicture}
};

\node[rectangle, fill=red!20, draw, scale=0.2, minimum size=20em,above = 2cm of y2] at (1, 2) (
    gauss2) {
        \begin{tikzpicture}
                \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                        \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                \end{axis}
        \end{tikzpicture}
};

\node[rectangle, fill=red!20, draw, scale=0.2, minimum size=20em,above = 2cm of y3] at (3, 2) (
    gauss3) {
        \begin{tikzpicture}
                \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                        \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                \end{axis}
        \end{tikzpicture}
};

\node at (5, 4.7) (gaussmd) {\dots};

\node[rectangle, fill=red!20, draw, scale=0.2, minimum size=20em,above = 2cm of yn] at (7, 2) (
    gaussn) {
        \begin{tikzpicture}
                \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                        \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                \end{axis}
        \end{tikzpicture}
};

\draw[-stealth, color=red, text=black, very thick, dotted]
        (y1) edge node[left] {$\mu_{id_0}^1$} node[right] {$\sigma_{id_0}^1$} (gauss1)
        (y2) edge node[left] {$\mu_{id_1}^1$} node[right] {$\sigma_{id_1}^1$} (gauss2)
        (y3) edge node[left] {$\mu_{id_2}^1$} node[right] {$\sigma_{id_2}^1$} (gauss3)
        (yn) edge node[left] {$\mu_{id_n}^1$} node[right] {$\sigma_{id_n}^1$} (gaussn);
%%%%%% BOUNDARY %%%%%%%

%%%%%% BOUNDARY %%%%%%%
\node[state, fill=echodrk!20, on chain=2, very thick, text depth=0pt] (21) at (0, -2) {$s_0$};
\node[state, fill=echodrk!20, on chain=2, very thick, text depth=0pt] (22) {$s_1$};
\node[state, fill=echodrk!20, on chain=2, very thick, text depth=0pt] (23) {$s_2$};
\node[on chain=2] (2md) {\dots};
\node[state, fill=echodrk!20, on chain=2, very thick, text depth=0pt] (2n) {$s_n$};
```

```
\draw[>=stealth, color=blue, text=black, very thick, auto=right,loop above/.style={out=75,in=105,
    loop}, every loop]
        (21) edge node[below] {\footnotesize$\boldsymbol \omega_{22}$} (22)
        (22) edge node[below] {\footnotesize$\boldsymbol \omega_{22}$} (23)
        (23) edge node[below] {\footnotesize$\boldsymbol \omega_{22}$} (2md)
        (2md) edge node[below] {\footnotesize$\boldsymbol \omega_{22}$} (2n);

\node[rectangle, thick, fill=echodrk!20, draw] at (-2, -3.7) (2y1) {$id_0$};
\node[rectangle, thick, fill=echodrk!20, draw] at (0, -3.7) (2y2) {$id_1$};
\node[rectangle, thick, fill=echodrk!20, draw] at (2, -3.7) (2y3) {$id_2$};
\node at (4, -3.7) (2ymd) {\dots};
\node[rectangle, thick, fill=echodrk!20, draw] at (6, -3.7) (2yn) {$id_n$};

\draw[-stealth, color=blue, text=black, very thick, dashed]
        (21) edge node[right] {${\bf O'}_{0,id_0}^2$} (2y1)
        (22) edge node[right] {${\bf O'}_{1,id_1}^2$} (2y2)
        (23) edge node[right] {${\bf O'}_{2,id_2}^2$} (2y3)
        (2n) edge node[right] {${\bf O'}_{n,id_n}^2$} (2yn);

\node[rectangle, fill=echodrk!20, draw, scale=0.2, minimum size=20em,above = 2cm of 2y1] at (-1,
    -9.5) (2gauss1) {
        \begin{tikzpicture}
                \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                        \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                \end{axis}
        \end{tikzpicture}
};

\node[rectangle, fill=echodrk!20, draw, scale=0.2, minimum size=20em,above = 2cm of 2y2] at (1,
    -9.5) (2gauss2) {
        \begin{tikzpicture}
                \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                        \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                \end{axis}
        \end{tikzpicture}
};

\node[rectangle, fill=echodrk!20, draw, scale=0.2, minimum size=20em,above = 2cm of 2y3] at (3,
    -9.5) (2gauss3) {
        \begin{tikzpicture}
                \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                        \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                \end{axis}
        \end{tikzpicture}
};

\node at (5, -6.8) (2gaussmd) {\dots};

\node[rectangle, fill=echodrk!20, draw, scale=0.2, minimum size=20em,above = 2cm of 2yn] at (7,
    -9.5) (2gaussn) {
        \begin{tikzpicture}
                \begin{axis}[axis lines=none, ticks=none,xmax=3, xmin=-3,ymax=1.1]
                        \addplot[ultra thick,black, no markers,samples=200] {exp(-x^2)};
                \end{axis}
        \end{tikzpicture}
};

\draw[-stealth, color=blue, text=black, very thick, dotted]
        (2y1) edge node[left] {$\mu_{id_0}^2$} node[right] {$\sigma_{id_0}^2$} (2gauss1)
        (2y2) edge node[left] {$\mu_{id_1}^2$} node[right] {$\sigma_{id_1}^2$} (2gauss2)
        (2y3) edge node[left] {$\mu_{id_2}^2$} node[right] {$\sigma_{id_2}^2$} (2gauss3)
        (2yn) edge node[left] {$\mu_{id_n}^2$} node[right] {$\sigma_{id_n}^2$} (2gaussn);

%%%% COMBO %%%%%
\draw[-stealth, very thick, auto=right,decoration={snake, segment length=2mm, amplitude=0.5mm,post
    length=1.5mm}]
        (1) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{12}$} (22)
        (2) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{12}$} (23)
        (3) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{12}$} (2md)
        (md) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{12}$} (2n);

\draw[-stealth, very thick, auto=right,decoration={snake, segment length=2mm, amplitude=0.5mm,post
    length=1.5mm}]
        (21) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{21}$} (2)
        (22) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{21}$} (3)
        (23) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{21}$} (md)
```

```
                (2md) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{21}$} (n);

        %%%% START STATES %%%%%
        \node[text depth=0pt] at (-2, -1) (S) {start};

        \draw[-stealth, very thick, auto=right,decoration={snake, segment length=2mm, amplitude=0.5mm,post
            length=1.5mm}]
                (S) edge[decorate] node[above] {\footnotesize$\pi_1$} (1)
                (S) edge[decorate] node[below] {\footnotesize$\pi_2$} (21);
\end{tikzpicture}
```

1.45 Multiplex Chain Gmhmm Beta



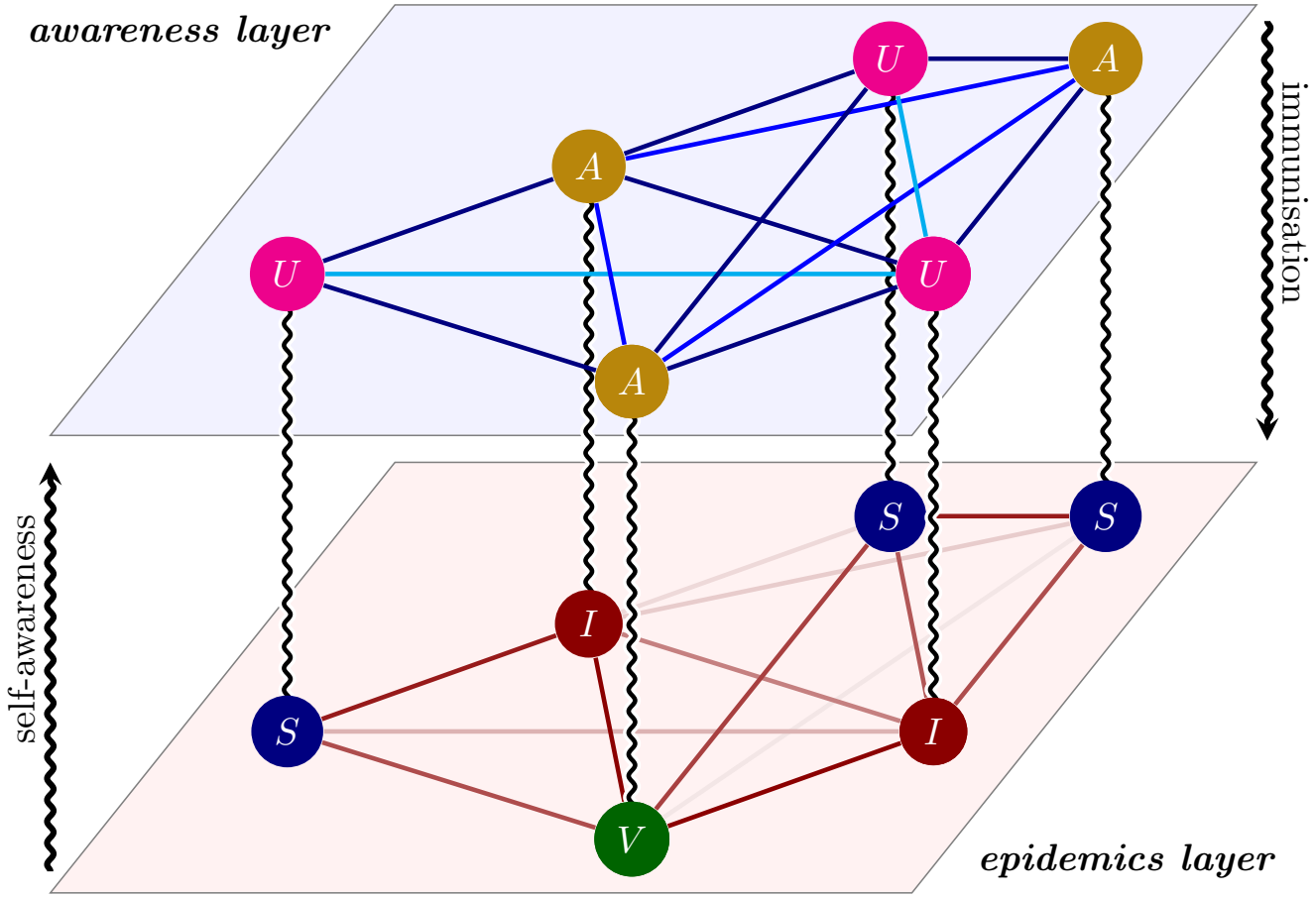
```
\definecolor{echodrk}{HTML}{0099cc}

\pgfmathdeclarefunction{gauss}{2}{%
  \pgfmathparse{1/(#2*sqrt(2*pi))*exp(-((x-#1)^2)/(2*#2^2))}%
}

\begin{tikzpicture} [scale=1.3, every node/.style={transform shape},start chain=1 going right, start chain
    =2 going right]

        \node[state, fill=red!20, on chain=1, very thick, text depth=0pt] (1) {$s_0$};
        \node[state, fill=red!20, on chain=1, very thick, text depth=0pt] (2) {$s_1$};
        \node[state, fill=red!20, on chain=1, very thick, text depth=0pt] (3) {$s_2$};
        \node[on chain=1] (md) {\dots};
        \node[state, fill=red!20, on chain=1, very thick, text depth=0pt] (n) {$s_n$};
        \draw[>=stealth, color=red, text=black, very thick, auto=right,loop above/.style={out=75,in=105,
            loop}, every loop]
                (1) edge node[above] {\footnotesize$\boldsymbol \omega_{11}$} (2)
                (2) edge node[above] {\footnotesize$\boldsymbol \omega_{11}$} (3)
                (3) edge node[above] {\footnotesize$\boldsymbol \omega_{11}$} (md)
                (md) edge node[above] {\footnotesize$\boldsymbol \omega_{11}$} (n);

        \node[rectangle, thick, fill=red!20, draw] at (-2, 1.7) (y1) {$id_0$};
        \node[rectangle, thick, fill=red!20, draw] at (0, 1.7) (y2) {$id_1$};
        \node[rectangle, thick, fill=red!20, draw] at (2, 1.7) (y3) {$id_2$};
        \node at (4, 1.7) (ymd) {\dots};
        \node[rectangle, thick, fill=red!20, draw] at (6, 1.7) (yn) {$id_n$};

        \draw[-stealth, color=red, text=black, very thick, dashed]
                (1) edge node[right] {${\bf O'}_{0,id_0}^1$} (y1)
                (2) edge node[right] {${\bf O'}_{1,id_1}^1$} (y2)
                (3) edge node[right] {${\bf O'}_{2,id_2}^1$} (y3)
                (n) edge node[right] {${\bf O'}_{n,id_n}^1$} (yn);

        \node[rectangle] at (-1, 4) (gauss1) {
                \begin{tikzpicture}
                        \begin{axis}[scale=0.25, axis on top, x tick label style={major tick length=0pt},
                            every axis plot post/.append style={mark=none,domain=-2:2,samples=50,smooth},
                                axis x line=bottom,
                                axis y line=left,
                                yticklabels={,,},
                                xticklabels={,,},
                                xtick=\empty, ytick=\empty,
                                enlargelimits=false, clip=false]
                                        \addplot[fill=red!10] {gauss(0,0.5)} \closedcycle;
                                        \draw[red!80,-stealth] (axis cs:0.5,0) -- (axis cs:0.5,0.47);
                        \end{axis}
                \end{tikzpicture}
        };

        \node[rectangle] at (1, 4) (gauss2) {
                \begin{tikzpicture}
                        \begin{axis}[scale=0.25, axis on top, x tick label style={major tick length=0pt},
                            every axis plot post/.append style={mark=none,domain=-5:5,samples=50,smooth},
                                axis x line=bottom,
                                axis y line=left,
                                yticklabels={,,},
                                xticklabels={,,},
                                xtick=\empty, ytick=\empty,
                                enlargelimits=false, clip=false]
                                        \addplot[fill=red!10] {gauss(-1,0.8)} \closedcycle;
                                        \draw[red!80,-stealth] (axis cs:-2.3,0) -- (axis cs:-2.3,0.121);
                        \end{axis}
                \end{tikzpicture}
        };

        \node[rectangle] at (3, 4) (gauss3) {
                \begin{tikzpicture}
                        \begin{axis}[scale=0.25, axis on top, x tick label style={major tick length=0pt},
                            every axis plot post/.append style={mark=none,domain=-4:4,samples=50,smooth},
                                axis x line=bottom,
                                axis y line=left,
                                yticklabels={,,},
                                xticklabels={,,},
                                xtick=\empty, ytick=\empty,
```

```
                        enlargelimits=false, clip=false]
                                \addplot[fill=red!10] {gauss(2,0.5)} \closedcycle;
                                \draw[red!80,-stealth] (axis cs:2.3,0) -- (axis cs:2.3,0.64);
                \end{axis}
        \end{tikzpicture}
};

\node at (5, 4) (gaussmd) {\dots};

\node[rectangle] at (7, 4) (gaussn) {
        \begin{tikzpicture}
                \begin{axis}[scale=0.25, axis on top, x tick label style={major tick length=0pt},
                    every axis plot post/.append style={mark=none,domain=-1.5:1.5,samples=50,smooth
                    },
                        axis x line=bottom,
                        axis y line=left,
                        yticklabels={,,},
                        xticklabels={,,},
                        xtick=\empty, ytick=\empty,
                        enlargelimits=false, clip=false]
                                \addplot[fill=red!10] {gauss(0.1,0.5)} \closedcycle;
                                \draw[red!80,-stealth] (axis cs:0.1,0) -- (axis cs:0.1,0.795);
                \end{axis}
        \end{tikzpicture}
};

\draw[-stealth, color=red, text=black, very thick, dotted]
        (y1) edge node[left] {$\mu_{id_0}^1$} node[right] {$\sigma_{id_0}^1$} (gauss1)
        (y2) edge node[left] {$\mu_{id_1}^1$} node[right] {$\sigma_{id_1}^1$} (gauss2)
        (y3) edge node[left] {$\mu_{id_2}^1$} node[right] {$\sigma_{id_2}^1$} (gauss3)
        (yn) edge node[left] {$\mu_{id_n}^1$} node[right] {$\sigma_{id_n}^1$} (gaussn);
%%%%%% BOUNDARY %%%%%%%

%%%%%% BOUNDARY %%%%%%%
\node[state, fill=echodrk!20, on chain=2, very thick, text depth=0pt] (21) at (0, -2) {$s_0$};
\node[state, fill=echodrk!20, on chain=2, very thick, text depth=0pt] (22) {$s_1$};
\node[state, fill=echodrk!20, on chain=2, very thick, text depth=0pt] (23) {$s_2$};
\node[on chain=2] (2md) {\dots};
\node[state, fill=echodrk!20, on chain=2, very thick, text depth=0pt] (2n) {$s_n$};
\draw[>=stealth, color=blue, text=black, very thick, auto=right,loop above/.style={out=75,in=105,
    loop}, every loop]
        (21) edge node[below] {\footnotesize$\boldsymbol \omega_{22}$} (22)
        (22) edge node[below] {\footnotesize$\boldsymbol \omega_{22}$} (23)
        (23) edge node[below] {\footnotesize$\boldsymbol \omega_{22}$} (2md)
        (2md) edge node[below] {\footnotesize$\boldsymbol \omega_{22}$} (2n);

\node[rectangle, thick, fill=echodrk!20, draw] at (-2, -3.7) (2y1) {$id_0$};
\node[rectangle, thick, fill=echodrk!20, draw] at (0, -3.7) (2y2) {$id_1$};
\node[rectangle, thick, fill=echodrk!20, draw] at (2, -3.7) (2y3) {$id_2$};
\node at (4, -3.7) (2ymd) {\dots};
\node[rectangle, thick, fill=echodrk!20, draw] at (6, -3.7) (2yn) {$id_n$};

\draw[-stealth, color=blue, text=black, very thick, dashed]
        (21) edge node[right] {${\bf O'}_{0,id_0}^2$} (2y1)
        (22) edge node[right] {${\bf O'}_{1,id_1}^2$} (2y2)
        (23) edge node[right] {${\bf O'}_{2,id_2}^2$} (2y3)
        (2n) edge node[right] {${\bf O'}_{n,id_n}^2$} (2yn);

\node[rectangle] at (-1, -6) (2gauss1) {
        \begin{tikzpicture}
                \begin{axis}[scale=0.25, axis on top, x tick label style={major tick length=0pt},
                    every axis plot post/.append style={mark=none,domain=-4:4,samples=50,smooth},
                        axis x line=bottom,
                        axis y line=left,
                        yticklabels={,,},
                        xticklabels={,,},
                        xtick=\empty, ytick=\empty,
                        enlargelimits=false, clip=false]
                                \addplot[fill=echodrk!10] {gauss(2,0.5)} \closedcycle;
                                \draw[blue!80,-stealth] (axis cs:2.3,0) -- (axis cs:2.3,0.64);
                \end{axis}
        \end{tikzpicture}
};

\node[rectangle] at (1, -6) (2gauss2) {
        \begin{tikzpicture}
```

```
                \begin{axis}[scale=0.25, axis on top, x tick label style={major tick length=0pt},
                    every axis plot post/.append style={mark=none,domain=-1.5:1.5,samples=50,smooth
                    },
                        axis x line=bottom,
                        axis y line=left,
                        yticklabels={,,},
                        xticklabels={,,},
                        xtick=\empty, ytick=\empty,
                        enlargelimits=false, clip=false]
                                \addplot[fill=echodrk!10] {gauss(0.1,0.5)} \closedcycle;
                                \draw[blue!80,-stealth] (axis cs:0.1,0) -- (axis cs:0.1,0.795);
                \end{axis}
        \end{tikzpicture}
};

\node[rectangle] at (3, -6) (2gauss3) {
        \begin{tikzpicture}
                \begin{axis}[scale=0.25, axis on top, x tick label style={major tick length=0pt},
                    every axis plot post/.append style={mark=none,domain=-2:2,samples=50,smooth},
                        axis x line=bottom,
                        axis y line=left,
                        yticklabels={,,},
                        xticklabels={,,},
                        xtick=\empty, ytick=\empty,
                        enlargelimits=false, clip=false]
                                \addplot[fill=echodrk!10] {gauss(0,0.5)} \closedcycle;
                                \draw[blue!80,-stealth] (axis cs:0.5,0) -- (axis cs:0.5,0.47);
                \end{axis}
        \end{tikzpicture}
};

\node at (5, -6) (2gaussmd) {\dots};

\node[rectangle] at (7, -6) (2gaussn) {
        \begin{tikzpicture}
                \begin{axis}[scale=0.25, axis on top, x tick label style={major tick length=0pt},
                    every axis plot post/.append style={mark=none,domain=-5:5,samples=50,smooth},
                        axis x line=bottom,
                        axis y line=left,
                        yticklabels={,,},
                        xticklabels={,,},
                        xtick=\empty, ytick=\empty,
                        enlargelimits=false, clip=false]
                                \addplot[fill=echodrk!10] {gauss(-1,0.8)} \closedcycle;
                                \draw[blue!80,-stealth] (axis cs:-2.3,0) -- (axis cs:-2.3,0.121);
                \end{axis}
        \end{tikzpicture}
};

\draw[-stealth, color=blue, text=black, very thick, dotted]
        (2y1) edge node[left] {$\mu_{id_0}^2$} node[right] {$\sigma_{id_0}^2$} (2gauss1)
        (2y2) edge node[left] {$\mu_{id_1}^2$} node[right] {$\sigma_{id_1}^2$} (2gauss2)
        (2y3) edge node[left] {$\mu_{id_2}^2$} node[right] {$\sigma_{id_2}^2$} (2gauss3)
        (2yn) edge node[left] {$\mu_{id_n}^2$} node[right] {$\sigma_{id_n}^2$} (2gaussn);

%%%% COMBO %%%%%
\draw[-stealth, very thick, auto=right,decoration={snake, segment length=2mm, amplitude=0.5mm,post
    length=1.5mm}]
        (1) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{12}$} (22)
        (2) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{12}$} (23)
        (3) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{12}$} (2md)
        (md) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{12}$} (2n);

\draw[-stealth, very thick, auto=right,decoration={snake, segment length=2mm, amplitude=0.5mm,post
    length=1.5mm}]
        (21) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{21}$} (2)
        (22) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{21}$} (3)
        (23) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{21}$} (md)
        (2md) edge[decorate] node[left, near start] {\footnotesize$\boldsymbol \omega_{21}$} (n);

%%%% START STATES %%%%%
\node[text depth=0pt] at (-2, -1) (S) {start};

\draw[-stealth, very thick, auto=right,decoration={snake, segment length=2mm, amplitude=0.5mm,post
    length=1.5mm}]
        (S) edge[decorate] node[above] {\footnotesize$\pi_1$} (1)
```

```
            (S) edge[decorate] node[below] {\footnotesize$\pi_2$} (21);
\end{tikzpicture}
```

1.46 Multiplex Epidemic Awareness Network

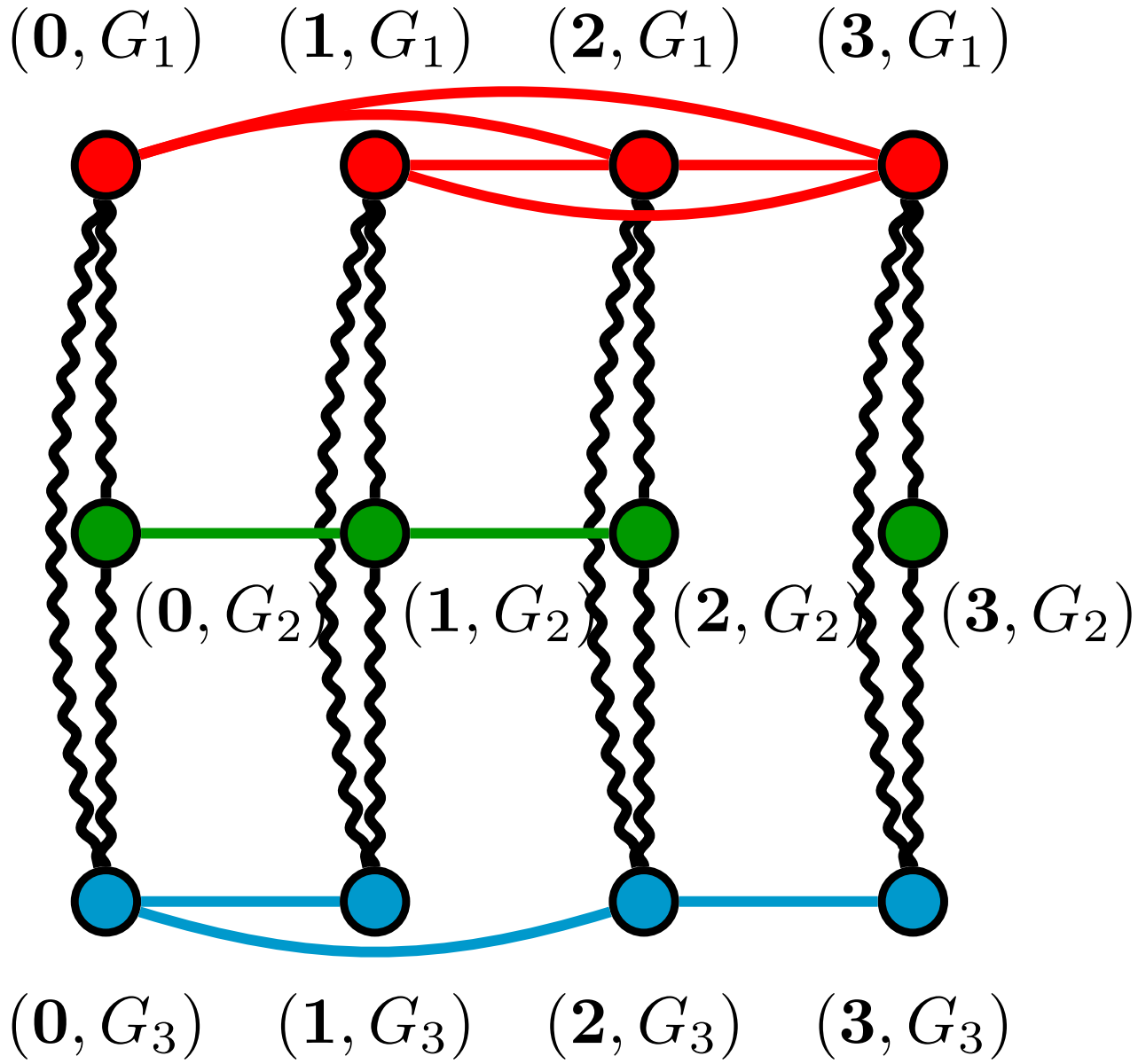



```
\definecolor{mynavy}{HTML}{000080}
\definecolor{darkred}{HTML}{8B0000}
\definecolor{mygreen}{HTML}{006400}
\definecolor{mygold}{HTML}{B8860B}

\newcommand{\myGlobalTransformation}[2]
{
    \pgftransformcm{1}{0}{0.4}{0.5}{\pgfpoint{#1cm}{#2cm}}
}

\tikzstyle myBG=[line width=3pt,opacity=1.0]

\begin{tikzpicture}

        \begin{scope}
                \myGlobalTransformation{0}{0};
                \draw [black!50,fill=red!5] rectangle (8,8);
        \end{scope}

        \begin{scope}
                \myGlobalTransformation{0}{4.25};
                \draw [black!50,fill=blue!5] rectangle (8,8);
        \end{scope}

        \begin{scope}
                \myGlobalTransformation{0}{0};
                \node (thisNode) at (1,3) {};
                {
                        \pgftransformreset
                        \draw[white,myBG,decoration={snake, pre length=0.01mm, segment length=2mm,
                            amplitude=0.3mm, post length=1.5mm}, decorate]  (thisNode) -- ++(0,4.25);
```

```
                \draw[black,very thick, decoration={snake, pre length=0.01mm, segment length=2mm,
                    amplitude=0.3mm, post length=1.5mm}, decorate,] (thisNode) -- ++(0,4.25);
        }
        \node (thisNode) at (3,5) {};
        {
                \pgftransformreset
                \draw[white,myBG,decoration={snake, pre length=0.01mm, segment length=2mm,
                    amplitude=0.3mm, post length=1.5mm}, decorate]  (thisNode) -- ++(0,4.25);
                \draw[black,very thick,decoration={snake, pre length=0.01mm, segment length=2mm,
                    amplitude=0.3mm, post length=1.5mm}, decorate] (thisNode) -- ++(0,4.25);
        }
        \node (thisNode) at (5,7) {};
        {
                \pgftransformreset
                \draw[white,myBG,decoration={snake, pre length=0.01mm, segment length=2mm,
                    amplitude=0.3mm, post length=1.5mm}, decorate]  (thisNode) -- ++(0,4.25);
                \draw[black,very thick,decoration={snake, pre length=0.01mm, segment length=2mm,
                    amplitude=0.3mm, post length=1.5mm}, decorate] (thisNode) -- ++(0,4.25);
        }
    \node (thisNode) at (7,7) {};
        {
                \pgftransformreset
                \draw[white,myBG,decoration={snake, pre length=0.01mm, segment length=2mm,
                    amplitude=0.3mm, post length=1.5mm}, decorate]  (thisNode) -- ++(0,4.25);
                \draw[black,very thick,decoration={snake, pre length=0.01mm, segment length=2mm,
                    amplitude=0.3mm, post length=1.5mm}, decorate] (thisNode) -- ++(0,4.25);
        }
\end{scope}

    \begin{scope}
        \myGlobalTransformation{0}{0}
        \node (N1) at (1,3) [circle,white,fill=mynavy] {$S$};
        \node (N2) at (3,5) [circle,white,fill=darkred] {$I$};
        \node (N3) at (5,1) [circle,white,fill=mygreen] {$V$};
        \node (N4) at (5,7) [circle,white,fill=mynavy] {$S$};
        \node (N5) at (7,3) [circle,white,fill=darkred] {$I$};
        \node (N6) at (7,7) [circle,white,fill=mynavy] {$S$};

        \draw[-, darkred!10, very thick] (N3) -- (N6);
        \draw[-, darkred!15, very thick] (N2) -- (N4);
        \draw[-, darkred!20, very thick] (N2) -- (N6);
        \draw[-, darkred!30, very thick] (N1) -- (N5);
        \draw[-, darkred!50, very thick] (N2) -- (N5);
        \draw[-, darkred!66, very thick] (N4) -- (N5);
        \draw[-, darkred!70, very thick] (N1) -- (N3);
        \draw[-, darkred!70, very thick] (N5) -- (N6);
        \draw[-, darkred!75, very thick] (N3) -- (N4);
        \draw[-, darkred!90, very thick] (N1) -- (N2);
        \draw[-, darkred!90, very thick] (N4) -- (N6);
        \draw[-, darkred, very thick] (N2) -- (N3);
        \draw[-, darkred, very thick] (N3) -- (N5);
    \end{scope}

    \begin{scope}
        \myGlobalTransformation{0}{4.25}
        \node (N1) at (1,3) [circle,white,fill=magenta] {$U$};
        \node (N2) at (3,5) [circle,white,fill=mygold] {$A$};
        \node (N3) at (5,1) [circle,white,fill=mygold] {$A$};
        \node (N4) at (5,7) [circle,white,fill=magenta] {$U$};
        \node (N5) at (7,3) [circle,white,fill=magenta] {$U$};
        \node (N6) at (7,7) [circle,white,fill=mygold] {$A$};

        \draw[-, mynavy, very thick] (N1) -- (N2);
        \draw[-, mynavy, very thick] (N1) -- (N3);
        \draw[-, cyan, very thick] (N1) -- (N5);

        \draw[-, blue, very thick] (N2) -- (N3);
        \draw[-, mynavy, very thick] (N2) -- (N4);
        \draw[-, mynavy, very thick] (N2) -- (N5);
        \draw[-, blue, very thick] (N2) -- (N6);

        \draw[-, mynavy, very thick] (N3) -- (N4);
        \draw[-, mynavy, very thick] (N3) -- (N5);
        \draw[-, blue, very thick] (N3) -- (N6);

        \draw[-, cyan, very thick] (N4) -- (N5);
```

```
                \draw[-, mynavy, very thick] (N4) -- (N6);

                \draw[-, mynavy, very thick] (N5) -- (N6);
        \end{scope}

        \begin{scope}
                \myGlobalTransformation{0}{0};
                \node (thisNode) at (5,1) {};
                {
                        \pgftransformreset
                        \draw[white,myBG,decoration={snake, pre length=0.01mm, segment length=2mm,
                            amplitude=0.3mm, post length=1.5mm}, decorate]  (thisNode) -- ++(0,4.25);
                        \draw[black,very thick,decoration={snake, pre length=0.01mm, segment length=2mm,
                            amplitude=0.3mm, post length=1.5mm}, decorate] (thisNode) -- ++(0,4.25);
                }
                \node (thisNode) at (7,3) {};
                {
                        \pgftransformreset
                        \draw[white,myBG,decoration={snake, pre length=0.01mm, segment length=2mm,
                            amplitude=0.3mm, post length=1.5mm}, decorate]  (thisNode) -- ++(0,4.25);
                        \draw[black,very thick,decoration={snake, pre length=0.01mm, segment length=2mm,
                            amplitude=0.3mm, post length=1.5mm}, decorate] (thisNode) -- ++(0,4.25);
                }
        \end{scope}

        \begin{scope}
                \myGlobalTransformation{0}{0}
                \node (N3) at (5,1) [circle,white,fill=mygreen] {$V$};
                \node (N5) at (7,3) [circle,white,fill=darkred] {$I$};
        \end{scope}

        \begin{scope}
                \myGlobalTransformation{0}{4.25}
                \node (N3) at (5,1) [circle,white,fill=mygold] {$A$};
                \node (N5) at (7,3) [circle,white,fill=magenta] {$U$};
        \end{scope}

        \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
            length=1.5mm}, decorate,ultra thick] (0, 0.2) -- node [above=1em,rotate=90] {self-awareness}
            (0, 4);

        \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
            length=1.5mm}, decorate,ultra thick] (11.3, 8.1) -- node [above=1em,rotate=-90] {immunisation}
            (11.3, 4.2);

        \node at (10, 0.3) {\emph{\textbf{epidemics layer}}};
        \node at (1.2, 8) {\emph{\textbf{awareness layer}}};

\end{tikzpicture}
```

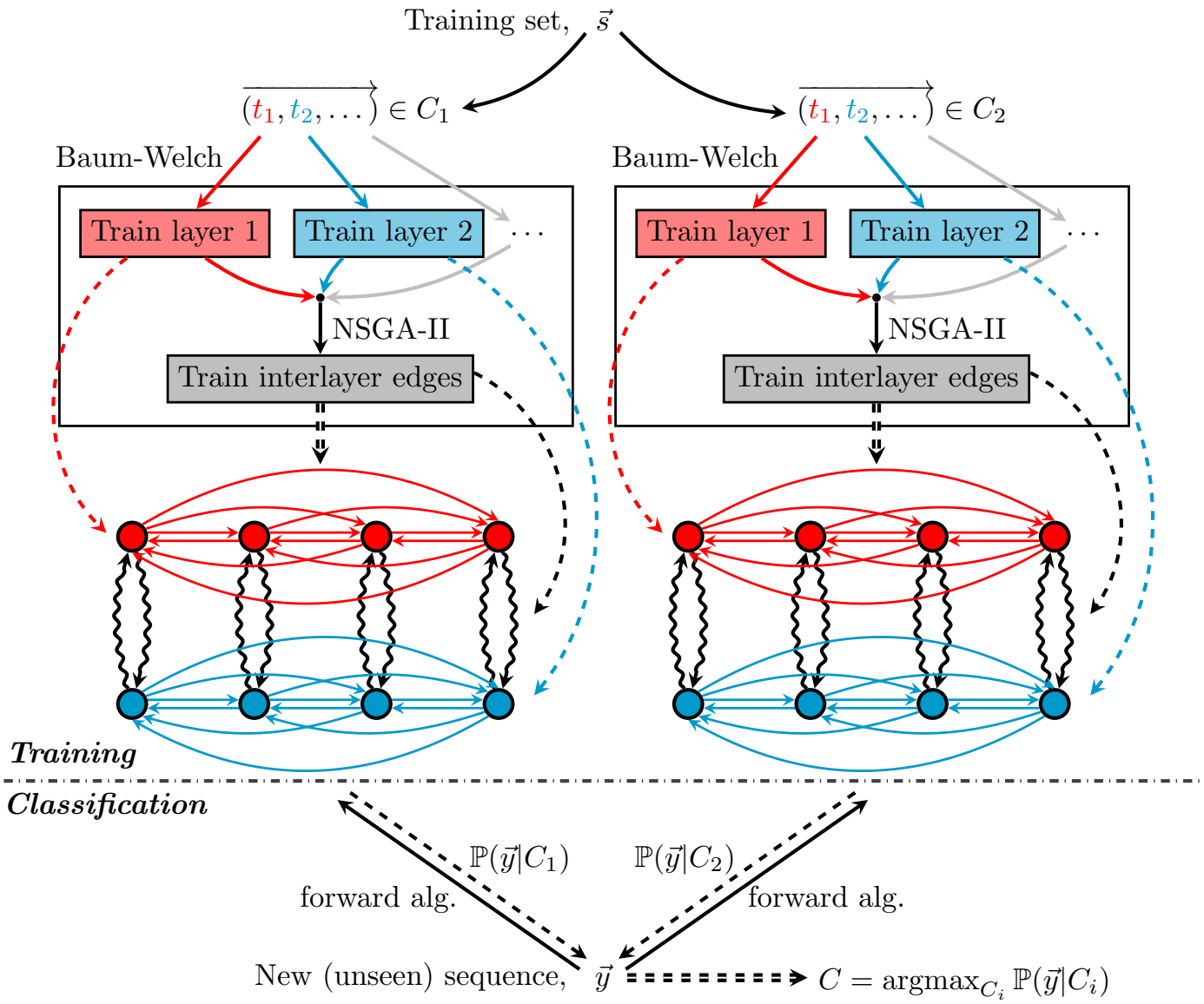
1.47 Multiplex Network Underlying Graph




```
\definecolor{mygreen}{rgb}{0,0.6,0}
\definecolor{echodrk}{HTML}{0099cc}

\begin{tikzpicture}
        \node[circle, draw, very thick, fill=echodrk] (11) {};
        \node[below = 0.5em of 11] (11c) {$({\bf 0}, G_3)$};
        \node[circle, draw, very thick, fill=echodrk, right=3em of 11] (22) {};
        \node[below =0.5em of 22] (22c) {$({\bf 1}, G_3)$};
        \node[circle, draw, very thick, fill=echodrk, right=3em of 22] (33) {};
        \node[below =0.5em of 33] (33c) {$({\bf 2}, G_3)$};
        \node[circle, draw, very thick, fill=echodrk, right=3em of 33] (44) {};
        \node[below =0.5em of 44] (44c) {$({\bf 3}, G_3)$};

        \node[circle, draw, very thick, fill=mygreen, above = 4.5em of 11] (111) {};
        \node at ([shift={(0.53,-0.3)}]111.-45) {$({\bf 0}, G_2)$};
        \node[circle, draw, very thick, fill=mygreen, right=3em of 111] (222) {};
        \node at ([shift={(0.53,-0.3)}]222.-45) {$({\bf 1}, G_2)$};
        \node[circle, draw, very thick, fill=mygreen, right=3em of 222] (333) {};
        \node at ([shift={(0.53,-0.3)}]333.-45) {$({\bf 2}, G_2)$};
        \node[circle, draw, very thick, fill=mygreen, right=3em of 333] (444) {};
        \node at ([shift={(0.53,-0.3)}]444.-45) {$({\bf 3}, G_2)$};

        \node[circle, draw, very thick, fill=red, above = 4.5em of 111] (1) {};
```

```
        \node[above = 0.5em of 1] (1c) {$({\bf 0}, G_1)$};
        \node[circle, draw, very thick, fill=red, right=3em of 1] (2) {};
        \node[above =0.5em of 2] (2c) {$({\bf 1}, G_1)$};
        \node[circle, draw, very thick, fill=red, right=3em of 2] (3) {};
        \node[above =0.5em of 3] (3c) {$({\bf 2}, G_1)$};
        \node[circle, draw, very thick, fill=red, right=3em of 3] (4) {};
        \node[above =0.5em of 4] (3c) {$({\bf 3}, G_1)$};


        \draw[ultra thick, -, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=0.2mm}, decorate] (11) to (111);
        \draw[ultra thick, -, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=0.2mm}, decorate] (22) to (222);
        \draw[ultra thick, -, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=0.2mm}, decorate] (33) to (333);
        \draw[ultra thick, -, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=0.2mm}, decorate] (44) to (444);

        \draw[ultra thick, -, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=0.2mm}, decorate] (1) to (111);
        \draw[ultra thick, -, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=0.2mm}, decorate] (2) to (222);
        \draw[ultra thick, -, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=0.2mm}, decorate] (3) to (333);
        \draw[ultra thick, -, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=0.2mm}, decorate] (4) to (444);

        \draw[ultra thick, -, bend right=12, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=0.2mm}, decorate] (1) to (11);
        \draw[ultra thick, -, bend right=12, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=0.2mm}, decorate] (2) to (22);
        \draw[ultra thick, -, bend right=12, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=0.2mm}, decorate] (3) to (33);
        \draw[ultra thick, -, bend right=12, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=0.2mm}, decorate] (4) to (44);

        \draw[-, ultra thick, color=echodrk] (11) to (22);
        \draw[-, ultra thick, bend right=17, color=echodrk] (11) to (33);
        \draw[-, ultra thick, color=echodrk] (33) to (44);

        \draw[-, ultra thick, color=mygreen] (111) to (222);
        \draw[-, ultra thick, color=mygreen] (222) to (333);

        \draw[-, ultra thick, bend left=17, color=red] (1) to (3);
        \draw[-, ultra thick, bend left=17, color=red] (1) to (4);
        \draw[-, ultra thick, bend right=17, color=red] (2) to (4);
        \draw[-, ultra thick, color=red] (2) to (3);
        \draw[-, ultra thick, color=red] (3) to (4);

\end{tikzpicture}
```

1.48 Muxstep Pipeline



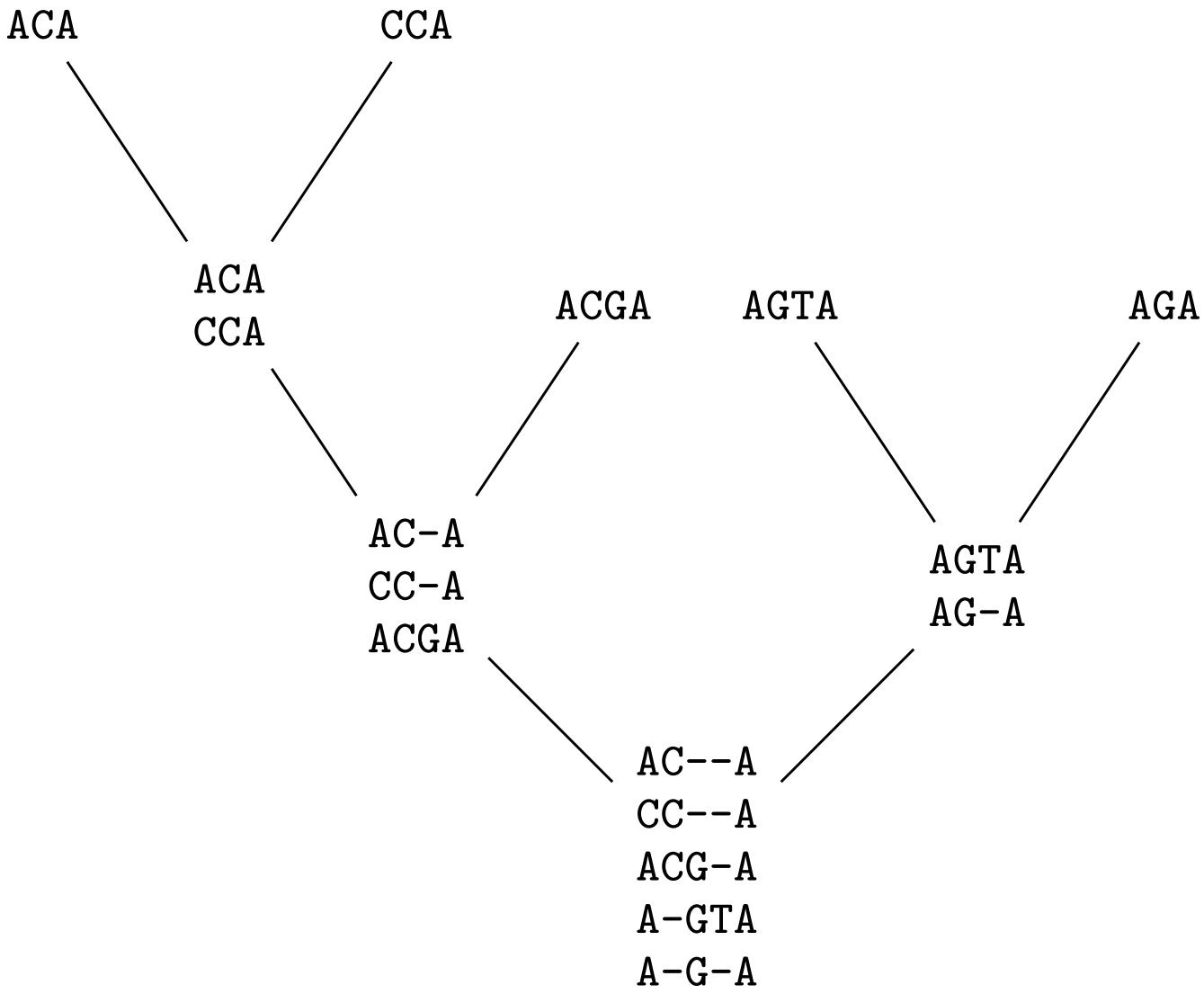

```
\definecolor{echodrk}{HTML}{0099cc}

\newcommand{\argmax}{\operatornamewithlimits{argmax}}

\begin{tikzpicture}[node distance=2.5cm]

        \draw[-, dashdotted, darkgray, very thick] (-2, -6.4) to (12, -6.4);
        \node[rectangle] at (-1.2, -6.1) {\emph{\textbf{Training}}};
        \node[rectangle] at (-0.8, -6.7) {\emph{\textbf{Classification}}};

        \node[circle, inner sep=0.2em, text depth=0em] (S) at (5, 2.5) {$\vec{s}$};
        \node[left = 0em of S, text depth=0em] (Slab) {Training set, };

        \node[rectangle] (out1) at (2,1.5) {$\overrightarrow{(\textcolor{red}{t_1}, \textcolor{echodrk}{t
            _2}, \dots)} \in C_1$};

        \node[rectangle] (out2) at (8.5,1.5) {$\overrightarrow{(\textcolor{red}{t_1}, \textcolor{echodrk}{t
            _2}, \dots)} \in C_2$};

        \draw[-stealth, very thick, bend left=20] (S) to (out1);
        \draw[-stealth, very thick, bend right=20] (S) to (out2);

        \node[rectangle, thick, draw, fill=red!50] (L1P) at (0, 0) {Train layer 1};
        \node[rectangle, thick, draw, fill=echodrk!50] (L2P) at (2.5, 0) {Train layer 2};
        \node[rectangle] (L3P) at (4.15, 0) {\dots};

        \node[circle,black,fill, inner sep=0.1em] (CP) at (1.7, -0.75){};
```

```
\node[rectangle, thick, draw, fill=lightgray] (NP) at (1.7, -1.7) {Train interlayer edges};
\node [draw,thick,minimum width=6cm,minimum height=2.8cm] (W1) at (1.65,-0.85) {};

\begin{scope}[shift={(6.5,0)}]
        \node[rectangle, thick, draw, fill=red!50] (L1N) at (0, 0) {Train layer 1};
        \node[rectangle, thick, draw, fill=echodrk!50] (L2N) at (2.5, 0) {Train layer 2};
        \node[rectangle] (L3N) at (4.15, 0) {\dots};

        \node[circle,black,fill, inner sep=0.1em] (CN) at (1.7, -0.75){};

        \node[rectangle, thick, draw, fill=lightgray] (NN) at (1.7, -1.7) {Train interlayer edges};
        \node [draw,thick,minimum width=6cm,minimum height=2.8cm] (W2) at (1.65,-0.85) {};
\end{scope}

\draw[-stealth, very thick, red] (out1.200) to node[above left=-0.3em] {\textcolor{black}{Baum-
    Welch}} (L1P);
\draw[-stealth, very thick, echodrk] (out1.220) to (L2P);
\draw[-stealth, very thick, lightgray] (out1.310) to (L3P);

\draw[-stealth, very thick, red, bend right=15] (L1P) to (CP);
\draw[-stealth, very thick, echodrk, bend right=15] (L2P) to (CP);
\draw[-stealth, very thick, lightgray, bend left=15] (L3P) to (CP);
\draw[-stealth, very thick] (CP) to node[right] {NSGA-II} (NP);

\draw[-stealth, dashed, red, very thick, bend right=50] (L1P) to (-0.8, -3.5);

\draw[-stealth, dashed, echodrk, very thick, bend left=50] (L2P) to (4.2, -5.4);

\draw[-stealth, dashed, very thick, bend left=50] (NP) to (4.2, -4.45);

\draw[-stealth, double, dashed, very thick] (NP) to (1.7, -2.7);

\draw[-stealth, very thick, red] (out2.200) to node[above left=-0.3em] {\textcolor{black}{Baum-
    Welch}} (L1N);
\draw[-stealth, very thick, echodrk] (out2.220) to (L2N);
\draw[-stealth, very thick, lightgray] (out2.310) to (L3N);

\draw[-stealth, very thick, red, bend right=15] (L1N) to (CN);
\draw[-stealth, very thick, echodrk, bend right=15] (L2N) to (CN);
\draw[-stealth, very thick, lightgray, bend left=15] (L3N) to (CN);
\draw[-stealth, very thick] (CN) to node[right] {NSGA-II} (NN);

\draw[-stealth, dashed, red, very thick, bend right=50] (L1N) to (5.7, -3.5);

\draw[-stealth, dashed, echodrk, very thick, bend left=50] (L2N) to (10.7, -5.4);

\draw[-stealth, dashed, very thick, bend left=50] (NN) to (10.7, -4.45);

\draw[-stealth, double, dashed, very thick] (NN) to (8.2, -2.7);

\node[circle, draw, very thick, fill=echodrk] (111) at (-0.5, -5.5) {};
\node[circle, draw, very thick, fill=echodrk, right=3em of 111] (222) {};
\node[circle, draw, very thick, fill=echodrk, right=3em of 222] (333) {};
\node[circle, draw, very thick, fill=echodrk, right=3em of 333] (444) {};

\node[circle, draw, very thick, fill=red, above = 4.5em of 111] (1) {};
\node[circle, draw, very thick, fill=red, right=3em of 1] (2) {};
\node[circle, draw, very thick, fill=red, right=3em of 2] (3) {};
\node[circle, draw, very thick, fill=red, right=3em of 3] (4) {};

\draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
    mm, post length=1.5mm}, decorate, bend left=15] (1) to (111);
\draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
    mm, post length=1.5mm}, decorate, bend left=15] (111) to (1);

\draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
    mm, post length=1.5mm}, decorate, bend left=15] (2) to (222);
\draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
    mm, post length=1.5mm}, decorate, bend left=15] (222) to (2);

\draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
    mm, post length=1.5mm}, decorate, bend left=15] (3) to (333);
\draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
    mm, post length=1.5mm}, decorate, bend left=15] (333) to (3);
```

```
\draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
    mm, post length=1.5mm}, decorate, bend left=15] (4) to (444);
\draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
    mm, post length=1.5mm}, decorate, bend left=15] (444) to (4);

\draw[-stealth, thick, bend left=17, color=echodrk] (111.30) to (333.130); % Consumption
\draw[-stealth, thick, bend left=30, color=echodrk] (111.50) to (444.90); % Consumption
\draw[-stealth, thick, bend left=17, color=echodrk] (222.30) to (444.130); % Consumption

\draw[stealth-, thick, bend right=17, color=echodrk] (111.310) to (333.210); % Consumption
\draw[stealth-, thick, bend right=30, color=echodrk] (111.270) to (444.230); % Consumption
\draw[stealth-, thick, bend right=17, color=echodrk] (222.310) to (444.210); % Consumption

\draw[stealth-, thick, color=echodrk] (111.345) to (222.195); % Consumption
\draw[-stealth, thick, color=echodrk] (111.15) to (222.165); % Consumption
\draw[stealth-, thick, color=echodrk] (222.345) to (333.195); % Consumption
\draw[-stealth, thick, color=echodrk] (222.15) to (333.165); % Consumption
\draw[stealth-, thick, color=echodrk] (333.345) to (444.195); % Consumption
\draw[-stealth, thick, color=echodrk] (333.15) to (444.165); % Consumption

\draw[-stealth, thick, bend left=17, color=red] (1.30) to (3.130); % Consumption
\draw[-stealth, thick, bend left=30, color=red] (1.50) to (4.90); % Consumption
\draw[-stealth, thick, bend left=17, color=red] (2.30) to (4.130); % Consumption

\draw[stealth-, thick, bend right=17, color=red] (1.310) to (3.210); % Consumption
\draw[stealth-, thick, bend right=30, color=red] (1.270) to (4.230); % Consumption
\draw[stealth-, thick, bend right=17, color=red] (2.310) to (4.210); % Consumption

\draw[stealth-, thick, color=red] (1.345) to (2.195); % Consumption
\draw[-stealth, thick, color=red] (1.15) to (2.165); % Consumption
\draw[stealth-, thick, color=red] (2.345) to (3.195); % Consumption
\draw[-stealth, thick, color=red] (2.15) to (3.165); % Consumption
\draw[stealth-, thick, color=red] (3.345) to (4.195); % Consumption
\draw[-stealth, thick, color=red] (3.15) to (4.165); % Consumption

\begin{scope}[shift={(6.5,0)}]
        \node[circle, draw, very thick, fill=echodrk] (N111) at (-0.5, -5.5) {};
        \node[circle, draw, very thick, fill=echodrk, right=3em of N111] (N222) {};
        \node[circle, draw, very thick, fill=echodrk, right=3em of N222] (N333) {};
        \node[circle, draw, very thick, fill=echodrk, right=3em of N333] (N444) {};

        \node[circle, draw, very thick, fill=red, above = 4.5em of N111] (N1) {};
        \node[circle, draw, very thick, fill=red, right=3em of N1] (N2) {};
        \node[circle, draw, very thick, fill=red, right=3em of N2] (N3) {};
        \node[circle, draw, very thick, fill=red, right=3em of N3] (N4) {};

        \draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate, bend left=15] (N1) to (N111);
        \draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate, bend left=15] (N111) to (N1);

        \draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate, bend left=15] (N2) to (N222);
        \draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate, bend left=15] (N222) to (N2);

        \draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate, bend left=15] (N3) to (N333);
        \draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate, bend left=15] (N333) to (N3);

        \draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate, bend left=15] (N4) to (N444);
        \draw[very thick, -stealth, decoration={snake, pre length=0.01mm, segment length=2mm,
            amplitude=0.3mm, post length=1.5mm}, decorate, bend left=15] (N444) to (N4);

        \draw[-stealth, thick, bend left=17, color=echodrk] (N111.30) to (N333.130);
        \draw[-stealth, thick, bend left=30, color=echodrk] (N111.50) to (N444.90);
        \draw[-stealth, thick, bend left=17, color=echodrk] (N222.30) to (N444.130);

        \draw[stealth-, thick, bend right=17, color=echodrk] (N111.310) to (N333.210);
        \draw[stealth-, thick, bend right=30, color=echodrk] (N111.270) to (N444.230);
        \draw[stealth-, thick, bend right=17, color=echodrk] (N222.310) to (N444.210);

        \draw[stealth-, thick, color=echodrk] (N111.345) to (N222.195);
        \draw[-stealth, thick, color=echodrk] (N111.15) to (N222.165);
```

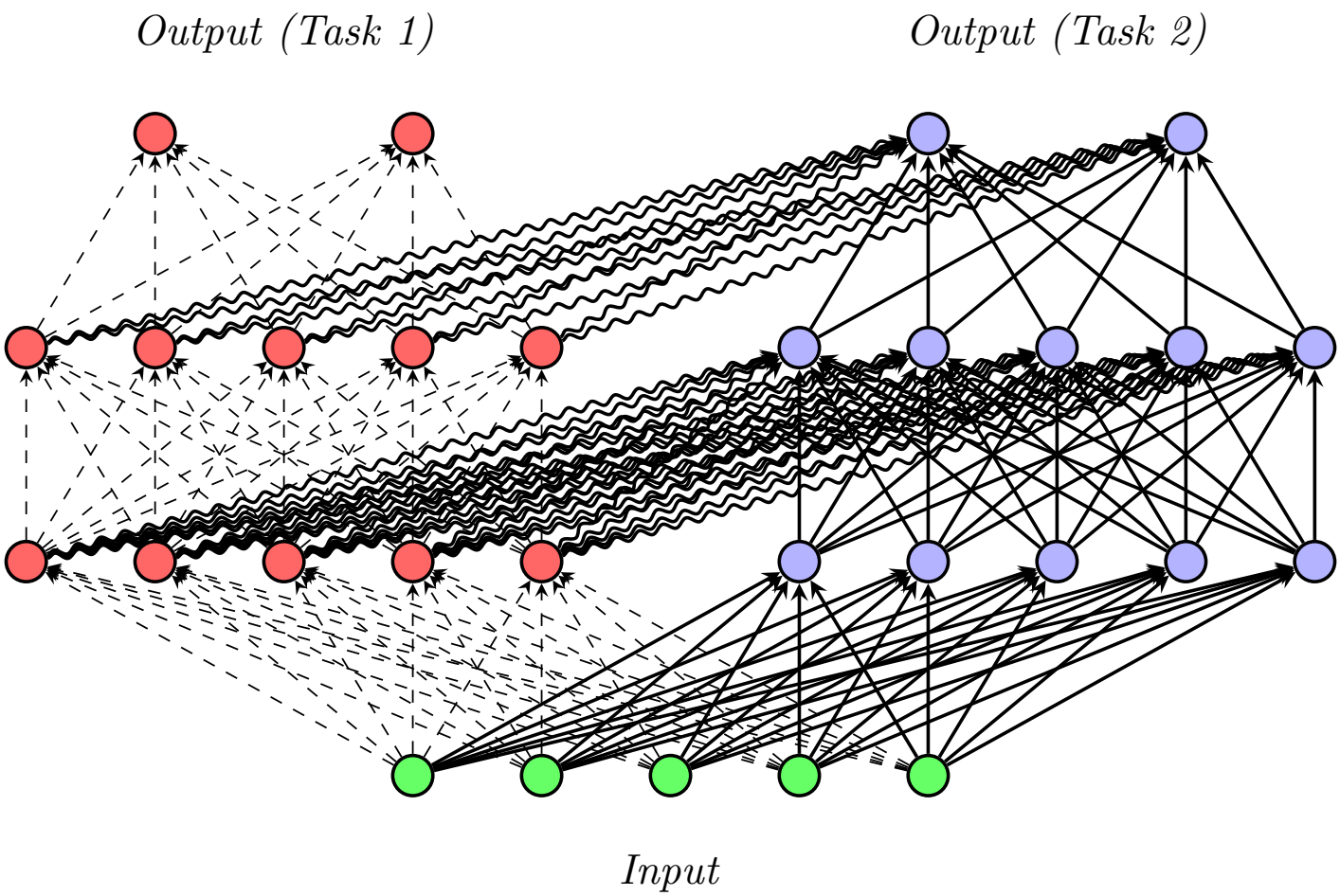
```
                \draw[stealth-, thick, color=echodrk] (N222.345) to (N333.195);
                \draw[-stealth, thick, color=echodrk] (N222.15) to (N333.165);
                \draw[stealth-, thick, color=echodrk] (N333.345) to (N444.195);
                \draw[-stealth, thick, color=echodrk] (N333.15) to (N444.165);

                \draw[-stealth, thick, bend left=17, color=red] (N1.30) to (N3.130);
                \draw[-stealth, thick, bend left=30, color=red] (N1.50) to (N4.90);
                \draw[-stealth, thick, bend left=17, color=red] (N2.30) to (N4.130);

                \draw[stealth-, thick, bend right=17, color=red] (N1.310) to (N3.210);
                \draw[stealth-, thick, bend right=30, color=red] (N1.270) to (N4.230);
                \draw[stealth-, thick, bend right=17, color=red] (N2.310) to (N4.210);

                \draw[stealth-, thick, color=red] (N1.345) to (N2.195);
                \draw[-stealth, thick, color=red] (N1.15) to (N2.165);
                \draw[stealth-, thick, color=red] (N2.345) to (N3.195);
                \draw[-stealth, thick, color=red] (N2.15) to (N3.165);
                \draw[stealth-, thick, color=red] (N3.345) to (N4.195);
                \draw[-stealth, thick, color=red] (N3.15) to (N4.165);
        \end{scope}

        \node[circle, inner sep=0.2em] (Y) at (5, -8.7) {$\vec{y}$};
        \node[left = 0em of Y] (Ylab) {New (unseen) sequence, };

        \node[circle] (imag1) at (1.9, -6.45) {};
        \node[circle] (imag2) at (8.1, -6.45) {};

        \draw[-stealth, very thick] (Y.160) to node[below left=-0.5em] {forward alg.} (imag1.270);
        \draw[-stealth, very thick] (Y.20) to node[below right=-0.5em] {forward alg.} (imag2.270);

        \draw[stealth-, dashed, very thick] (Y.130) to node[above right=-0.5em] {$\mathbb{P}(\vec{y}|C_1)$}
             (imag1.330);
        \draw[stealth-, dashed, very thick] (Y.50) to node[above left=-0.5em] {$\mathbb{P}(\vec{y}|C_2)$} (
            imag2.210);

        \node[rectangle, right= 6em of Y, text depth=0em] (ret) {$C = \argmax_{C_i} \mathbb{P}(\vec{y}|C_i)
            $};
        \draw[-stealth, double, dashed, very thick] (Y) to (ret);
\end{tikzpicture}
```

1.49 Progressive Alignment




```
\begin{tikzpicture}[font=\tt\scriptsize, grow=up, level 1/.style={sibling distance=30mm}, level 2/.style={
    sibling distance=20mm}]
        \node[align=center](0){AC{-}{-}A\\CC{-}{-}A\\ACG-A\\A-GTA\\A-G-A}
                child{node[align=center]{AGTA\\AG-A}
                        child{node{AGA}}
                        child{node{AGTA}}
                }
                child{node[align=center]{AC-A\\CC-A\\ACGA}
                        child{node{ACGA}}
                        child{node[align=center]{ACA\\CCA}
                                child{node{CCA}}
                                child{node{ACA}}
                        }
                };
\end{tikzpicture}
```

1.50 Progressive Neural Network



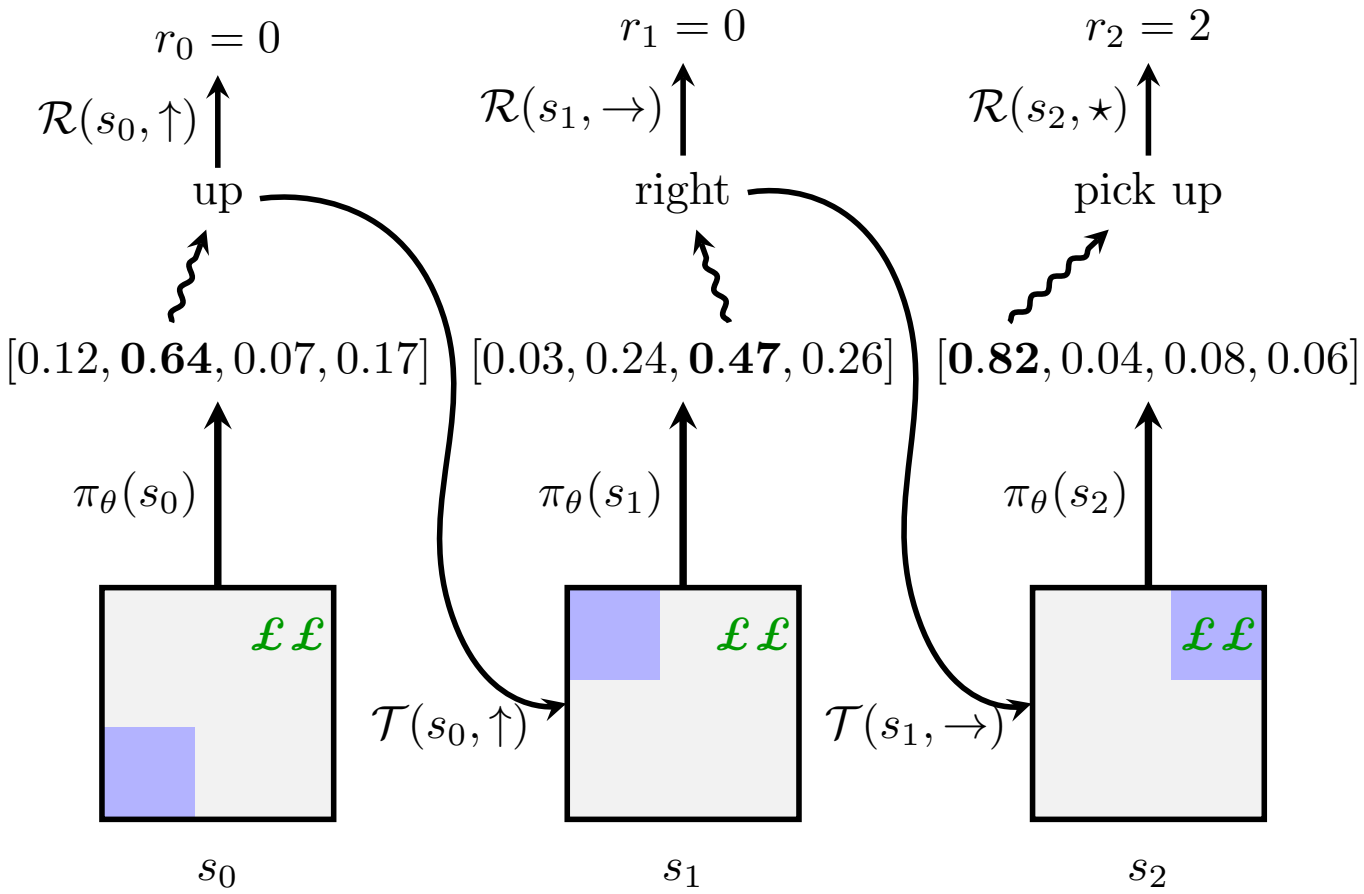

```
\begin{tikzpicture}
        \node[circle, draw, thick, fill=green!60] (i1) {};
        \node[circle, draw, thick, fill=green!60, right=2em of i1] (i2) {};
        \node[circle, draw, thick, fill=green!60, right=2em of i2] (i3) {};
        \node[circle, draw, thick, fill=green!60, left=2em of i1] (i4) {};
        \node[circle, draw, thick, fill=green!60, left=2em of i4] (i5) {};

        \node[below=1em of i1] (lab1) {\emph{Input}};

        \node[circle, draw, thick, fill=red!60,above=4em of i4] (h1) {};
        \node[circle, draw, thick, fill=red!60,left=2em of h1] (h2) {};
        \node[circle, draw, thick, fill=red!60, left=2em of h2] (h3) {};
        \node[circle, draw, thick, fill=red!60,left=2em of h3] (h4) {};
        \node[circle, draw, thick, fill=red!60, left=2em of h4] (h5) {};

        \node[circle, draw, thick, fill=red!60,above=4em of h1] (hh1) {};
        \node[circle, draw, thick, fill=red!60,above=4em of h2] (hh2) {};
        \node[circle, draw, thick, fill=red!60,above=4em of h3] (hh3) {};
        \node[circle, draw, thick, fill=red!60,above=4em of h4] (hh4) {};
        \node[circle, draw, thick, fill=red!60,above=4em of h5] (hh5) {};

        \node[circle, draw, thick, fill=red!60,above=4em of hh2] (o1) {};
        \node[circle, draw, thick, fill=red!60,above=4em of hh4] (o2) {};

        \draw[-stealth, thin, dashed] (i1) -- (h1);
        \draw[-stealth, thin, dashed] (i1) -- (h2);
        \draw[-stealth, thin, dashed] (i1) -- (h3);
        \draw[-stealth, thin, dashed] (i1) -- (h4);
        \draw[-stealth, thin, dashed] (i1) -- (h5);
        \draw[-stealth, thin, dashed] (i2) -- (h1);
        \draw[-stealth, thin, dashed] (i2) -- (h2);
        \draw[-stealth, thin, dashed] (i2) -- (h3);
        \draw[-stealth, thin, dashed] (i2) -- (h4);
        \draw[-stealth, thin, dashed] (i2) -- (h5);
```

```
\draw[-stealth, thin, dashed] (i3) -- (h1);
\draw[-stealth, thin, dashed] (i3) -- (h2);
\draw[-stealth, thin, dashed] (i3) -- (h3);
\draw[-stealth, thin, dashed] (i3) -- (h4);
\draw[-stealth, thin, dashed] (i3) -- (h5);
\draw[-stealth, thin, dashed] (i4) -- (h1);
\draw[-stealth, thin, dashed] (i4) -- (h2);
\draw[-stealth, thin, dashed] (i4) -- (h3);
\draw[-stealth, thin, dashed] (i4) -- (h4);
\draw[-stealth, thin, dashed] (i4) -- (h5);
\draw[-stealth, thin, dashed] (i5) -- (h1);
\draw[-stealth, thin, dashed] (i5) -- (h2);
\draw[-stealth, thin, dashed] (i5) -- (h3);
\draw[-stealth, thin, dashed] (i5) -- (h4);
\draw[-stealth, thin, dashed] (i5) -- (h5);

\draw[-stealth, thin, dashed] (h1) -- (hh1);
\draw[-stealth, thin, dashed] (h1) -- (hh2);
\draw[-stealth, thin, dashed] (h1) -- (hh3);
\draw[-stealth, thin, dashed] (h1) -- (hh4);
\draw[-stealth, thin, dashed] (h1) -- (hh5);
\draw[-stealth, thin, dashed] (h2) -- (hh1);
\draw[-stealth, thin, dashed] (h2) -- (hh2);
\draw[-stealth, thin, dashed] (h2) -- (hh3);
\draw[-stealth, thin, dashed] (h2) -- (hh4);
\draw[-stealth, thin, dashed] (h2) -- (hh5);
\draw[-stealth, thin, dashed] (h3) -- (hh1);
\draw[-stealth, thin, dashed] (h3) -- (hh2);
\draw[-stealth, thin, dashed] (h3) -- (hh3);
\draw[-stealth, thin, dashed] (h3) -- (hh4);
\draw[-stealth, thin, dashed] (h3) -- (hh5);
\draw[-stealth, thin, dashed] (h4) -- (hh1);
\draw[-stealth, thin, dashed] (h4) -- (hh2);
\draw[-stealth, thin, dashed] (h4) -- (hh3);
\draw[-stealth, thin, dashed] (h4) -- (hh4);
\draw[-stealth, thin, dashed] (h4) -- (hh5);
\draw[-stealth, thin, dashed] (h5) -- (hh1);
\draw[-stealth, thin, dashed] (h5) -- (hh2);
\draw[-stealth, thin, dashed] (h5) -- (hh3);
\draw[-stealth, thin, dashed] (h5) -- (hh4);
\draw[-stealth, thin, dashed] (h5) -- (hh5);


\draw[-stealth, thin, dashed] (hh1) -- (o1);
\draw[-stealth, thin, dashed] (hh1) -- (o2);
\draw[-stealth, thin, dashed] (hh2) -- (o1);
\draw[-stealth, thin, dashed] (hh2) -- (o2);
\draw[-stealth, thin, dashed] (hh3) -- (o1);
\draw[-stealth, thin, dashed] (hh3) -- (o2);
\draw[-stealth, thin, dashed] (hh4) -- (o1);
\draw[-stealth, thin, dashed] (hh4) -- (o2);
\draw[-stealth, thin, dashed] (hh5) -- (o1);
\draw[-stealth, thin, dashed] (hh5) -- (o2);

\node[above=6em of hh3] (lab1) {\emph{Output (Task 1)}};


\node[circle, draw, thick, fill=blue!30,above=4em of i2] (ih1) {};
\node[circle, draw, thick, fill=blue!30,right=2em of ih1] (ih2) {};
\node[circle, draw, thick, fill=blue!30,right=2em of ih2] (ih3) {};
\node[circle, draw, thick, fill=blue!30,right=2em of ih3] (ih4) {};
\node[circle, draw, thick, fill=blue!30,right=2em of ih4] (ih5) {};

\node[circle, draw, thick, fill=blue!30,above=4em of ih1] (ihh1) {};
\node[circle, draw, thick, fill=blue!30,above=4em of ih2] (ihh2) {};
\node[circle, draw, thick, fill=blue!30,above=4em of ih3] (ihh3) {};
\node[circle, draw, thick, fill=blue!30,above=4em of ih4] (ihh4) {};
\node[circle, draw, thick, fill=blue!30,above=4em of ih5] (ihh5) {};

\node[circle, draw, thick, fill=blue!30,above=4em of ihh2] (io1) {};
\node[circle, draw, thick, fill=blue!30,above=4em of ihh4] (io2) {};

\node[above=6em of ihh3] (lab1) {\emph{Output (Task 2)}};

\draw[-stealth, thick] (i1) -- (ih1);
\draw[-stealth, thick] (i1) -- (ih2);
```

```
        \draw[-stealth, thick] (i1) -- (ih3);
        \draw[-stealth, thick] (i1) -- (ih4);
        \draw[-stealth, thick] (i1) -- (ih5);
        \draw[-stealth, thick] (i2) -- (ih1);
        \draw[-stealth, thick] (i2) -- (ih2);
        \draw[-stealth, thick] (i2) -- (ih3);
        \draw[-stealth, thick] (i2) -- (ih4);
        \draw[-stealth, thick] (i2) -- (ih5);
        \draw[-stealth, thick] (i3) -- (ih1);
        \draw[-stealth, thick] (i3) -- (ih2);
        \draw[-stealth, thick] (i3) -- (ih3);
        \draw[-stealth, thick] (i3) -- (ih4);
        \draw[-stealth, thick] (i3) -- (ih5);
        \draw[-stealth, thick] (i4) -- (ih1);
        \draw[-stealth, thick] (i4) -- (ih2);
        \draw[-stealth, thick] (i4) -- (ih3);
        \draw[-stealth, thick] (i4) -- (ih4);
        \draw[-stealth, thick] (i4) -- (ih5);
        \draw[-stealth, thick] (i5) -- (ih1);
        \draw[-stealth, thick] (i5) -- (ih2);
        \draw[-stealth, thick] (i5) -- (ih3);
        \draw[-stealth, thick] (i5) -- (ih4);
        \draw[-stealth, thick] (i5) -- (ih5);

        \draw[-stealth, thick] (ih1) -- (ihh1);
        \draw[-stealth, thick] (ih1) -- (ihh2);
        \draw[-stealth, thick] (ih1) -- (ihh3);
        \draw[-stealth, thick] (ih1) -- (ihh4);
        \draw[-stealth, thick] (ih1) -- (ihh5);
        \draw[-stealth, thick] (ih2) -- (ihh1);
        \draw[-stealth, thick] (ih2) -- (ihh2);
        \draw[-stealth, thick] (ih2) -- (ihh3);
        \draw[-stealth, thick] (ih2) -- (ihh4);
        \draw[-stealth, thick] (ih2) -- (ihh5);
        \draw[-stealth, thick] (ih3) -- (ihh1);
        \draw[-stealth, thick] (ih3) -- (ihh2);
        \draw[-stealth, thick] (ih3) -- (ihh3);
        \draw[-stealth, thick] (ih3) -- (ihh4);
        \draw[-stealth, thick] (ih3) -- (ihh5);
        \draw[-stealth, thick] (ih4) -- (ihh1);
        \draw[-stealth, thick] (ih4) -- (ihh2);
        \draw[-stealth, thick] (ih4) -- (ihh3);
        \draw[-stealth, thick] (ih4) -- (ihh4);
        \draw[-stealth, thick] (ih4) -- (ihh5);
        \draw[-stealth, thick] (ih5) -- (ihh1);
        \draw[-stealth, thick] (ih5) -- (ihh2);
        \draw[-stealth, thick] (ih5) -- (ihh3);
        \draw[-stealth, thick] (ih5) -- (ihh4);
        \draw[-stealth, thick] (ih5) -- (ihh5);

        \draw[-stealth, thick] (ihh1) -- (io1);
        \draw[-stealth, thick] (ihh1) -- (io2);
        \draw[-stealth, thick] (ihh2) -- (io1);
        \draw[-stealth, thick] (ihh2) -- (io2);
        \draw[-stealth, thick] (ihh3) -- (io1);
        \draw[-stealth, thick] (ihh3) -- (io2);
        \draw[-stealth, thick] (ihh4) -- (io1);
        \draw[-stealth, thick] (ihh4) -- (io2);
        \draw[-stealth, thick] (ihh5) -- (io1);
        \draw[-stealth, thick] (ihh5) -- (io2);


        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h1) -- (ihh1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h1) -- (ihh2);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h1) -- (ihh3);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h1) -- (ihh4);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h1) -- (ihh5);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h2) -- (ihh1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h2) -- (ihh2);
```

```
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h2) -- (ihh3);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h2) -- (ihh4);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h2) -- (ihh5);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h3) -- (ihh1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h3) -- (ihh2);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h3) -- (ihh3);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h3) -- (ihh4);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h3) -- (ihh5);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h4) -- (ihh1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h4) -- (ihh2);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h4) -- (ihh3);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h4) -- (ihh4);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h4) -- (ihh5);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h5) -- (ihh1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h5) -- (ihh2);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h5) -- (ihh3);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h5) -- (ihh4);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (h5) -- (ihh5);


        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh1) -- (io1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh1) -- (io2);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh2) -- (io1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh2) -- (io2);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh3) -- (io1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh3) -- (io2);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh4) -- (io1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh4) -- (io2);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh5) -- (io1);
        \draw[-stealth, thick, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate,] (hh5) -- (io2);

\end{tikzpicture}
```

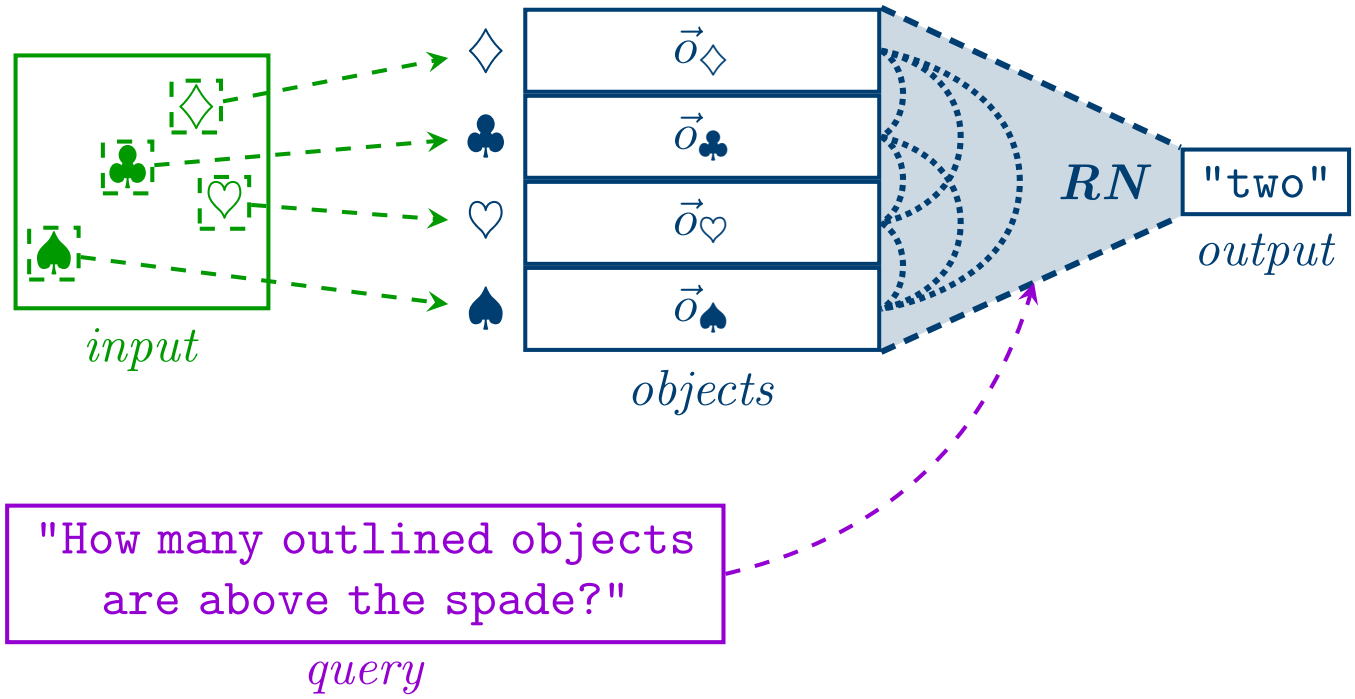
1.51 Reinforcement Learning Greedy Policy




```
\definecolor{olivegreen}{rgb}{0,0.6,0}

\begin{tikzpicture}
        \node[rectangle, minimum width=5em, minimum height=5em, fill=lightgray!20] (X) {};
        \node[rectangle, fill=blue!30, minimum width=2em, minimum height=2em, xshift=-1.5em, yshift=-1.5em]
             at (X) (AA) {};
        \node[rectangle, minimum width=2em, minimum height=2em, xshift=1.5em, yshift=1.5em, olivegreen] at
            (X) (LA) {$\boldsymbol\pounds\boldsymbol\pounds$};
        \node[rectangle, very thick, draw, minimum width=5em, minimum height=5em] at (X) (K) {};
        \node[rectangle, right=5em of X, minimum width=5em, minimum height=5em, fill=lightgray!20] (Y) {};
        \node[rectangle, fill=blue!30, minimum width=2em, minimum height=2em, xshift=-1.5em, yshift=1.5em]
            at (Y) (BB) {};
        \node[rectangle, minimum width=2em, minimum height=2em, xshift=1.5em, yshift=1.5em, olivegreen] at
            (Y) (LB) {$\boldsymbol\pounds\boldsymbol\pounds$};
        \node[rectangle, very thick, draw, minimum width=5em, minimum height=5em] at (Y) (W) {};
        \node[rectangle, right=5em of Y, minimum width=5em, minimum height=5em, fill=lightgray!20] (Z) {};
        \node[rectangle, fill=blue!30, minimum width=2em, minimum height=2em, xshift=1.5em, yshift=1.5em]
            at (Z) (CC) {};
        \node[rectangle, minimum width=2em, minimum height=2em, xshift=1.5em, yshift=1.5em, olivegreen] at
            (Z) (LC) {$\boldsymbol\pounds\boldsymbol\pounds$};
        \node[rectangle, very thick, draw, minimum width=5em, minimum height=5em] at (Z) (AS) {};

        \node[below=0.5em of X] (l1) {$s_0$};
        \node[below=0.5em of Y] (l2) {$s_1$};
        \node[below=0.5em of Z] (l3) {$s_2$};

        \node[above=4em of X] (P1) {$[0.12, {\bf 0.64}, 0.07, 0.17]$};
        \node[above=4em of Y] (P2) {$[0.03, 0.24, {\bf 0.47}, 0.26]$};
        \node[above=4em of Z] (P3) {$[{\bf 0.82}, 0.04, 0.08, 0.06]$};

        \draw[-stealth, ultra thick] (X) -- node[left] {$\pi_\theta(s_0)$} (P1);
        \draw[-stealth, ultra thick] (Y) -- node[left] {$\pi_\theta(s_1)$} (P2);
        \draw[-stealth, ultra thick] (Z) -- node[left] {$\pi_\theta(s_2)$} (P3);

        \node[above=2em of P1] (A1) {up};
        \node[above=2em of P2] (A2) {right};
```

```
        \node[above=2em of P3] (A3) {pick up};

        \draw[-stealth, very thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate] ([xshift=-1em]P1.north) -- (A1);
        \draw[-stealth, very thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate] ([xshift=1em]P2.north) -- (A2);
        \draw[-stealth, very thick,decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3
            mm, post length=1.5mm}, decorate] ([xshift=-3em]P3.north) -- (A3);

        \node[above=2em of A1] (R1) {$r_0 = 0$};
        \node[above=2em of A2] (R2) {$r_1 = 0$};
        \node[above=2em of A3] (R3) {$r_2 = 2$};

        \draw[-stealth, very thick] (A1) -- node[left] {$\mathcal{R}(s_0, \uparrow)$} (R1);
        \draw[-stealth, very thick] (A2) -- node[left] {$\mathcal{R}(s_1, \rightarrow)$} (R2);
        \draw[-stealth, very thick] (A3) -- node[left] {$\mathcal{R}(s_2, \star)$} (R3);

        \node[xshift=-2.5em, yshift=-0.5em] at (Y.west) {$\mathcal{T}(s_0, \uparrow)$} (R1);
        \node[xshift=-2.5em, yshift=-0.5em] at (Z.west) {$\mathcal{T}(s_1, \rightarrow)$} (R2);

        \draw [-stealth, very thick] plot [smooth, tension=1] coordinates { (A1.east) ([xshift=3.75em,
            yshift=-2em]A1.east) ([xshift=-2.5em,yshift=2em]Y.west) (Y.west)};
        \draw [-stealth, very thick] plot [smooth, tension=1] coordinates { (A2.east) ([xshift=3.25em,
            yshift=-2em]A2.east) ([xshift=-2.5em,yshift=2em]Z.west) (Z.west)};
\end{tikzpicture}
```

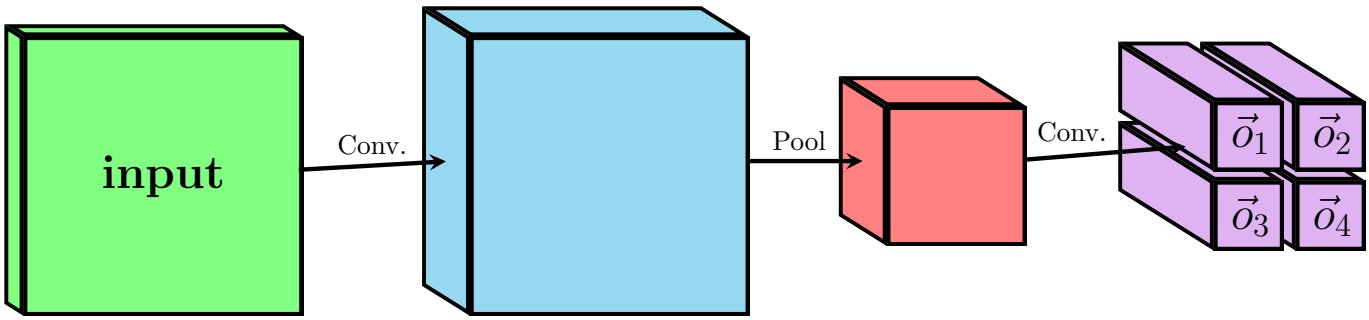
1.52 Relational Network




```
\definecolor{olivegreen}{rgb}{0,0.6,0}
\definecolor{mymauve}{rgb}{0.58,0,0.82}
\definecolor{camdrk}{RGB}{0,62,114}

\begin{tikzpicture}
        \node[rectangle, draw, thick, olivegreen, minimum width=5em, minimum height=5em] (R) at (0, 0) {};
        \node[rectangle, inner sep=0.1em, olivegreen,dashed, draw, thick] (C) at (-0.1, 0.1) {$\clubsuit$};
        \node[rectangle, thick, inner sep=0.1em, olivegreen,dashed, draw, above right=0.1em and 0.3em of C]
             (D) {$\diamondsuit$};
        \node[rectangle, thick, inner sep=0.1em, olivegreen,dashed, draw, below right=0.8em and -0.5em of D
            ] (H) {$\heartsuit$};
        \node[rectangle, thick, inner sep=0.1em, olivegreen,dashed, draw, below left=0.6em and 0.4em of C]
            (S) {$\spadesuit$};
        \node[olivegreen,below=0em of R] (l1) {\emph{input}};

        \node[camdrk, rectangle, draw, above right=-2.5em and 5em of R, minimum width=7em, thick]  (Oc) {$\
            vec{o}_\clubsuit$};
```

```
        \node[camdrk, rectangle, draw, above=0em of Oc, minimum width=7em, thick]  (Od) {$\vec{o}_\
            diamondsuit$};
        \node[camdrk, rectangle, draw, below=0em of Oc, minimum width=7em, thick]  (Oh) {$\vec{o}_\
            heartsuit$};
        \node[camdrk, rectangle, draw, below=0em of Oh, minimum width=7em, thick]  (Os) {$\vec{o}_\
            spadesuit$};

        \node[camdrk, left=0em of Oc] (lc) {$\clubsuit$};
        \node[camdrk, left=0em of Od] (ld) {$\diamondsuit$};
        \node[camdrk, left=0em of Oh] (lh) {$\heartsuit$};
        \node[camdrk, left=0em of Os] (ls) {$\spadesuit$};

        \node[camdrk, below=0em of Os] (lr) {\emph{objects}};

        \draw[olivegreen,-stealth, thick, dashed] (C) -- (lc);
        \draw[olivegreen,-stealth, thick, dashed] (D) -- (ld);
        \draw[olivegreen,-stealth, thick, dashed] (H) -- (lh);
        \draw[olivegreen,-stealth, thick, dashed] (S) -- (ls);

        \node[draw, camdrk, thick, right=18em of R] (A) {\texttt{"two"}};
        \node[camdrk, below=0em of A] {\emph{output}};

        \draw[camdrk, densely dashed, very thick] (Od.north east) -- (A.north west);
        \draw[camdrk, densely dashed, very thick] (Os.south east) -- (A.south west);

        \fill [opacity=0.2, camdrk] (Od.north east) -- (A.north west) -- (A.south west) -- (Os.south east)
            -- cycle;

        % let's get funky
        \node[right=14.75em of R, inner sep=0em] (dum1) {};
        \node[right=1.5em of Oc, inner sep=0em] (dum2) {};
        \node[right=1.5em of Oh, inner sep=0em] (dum3) {};

        \draw[camdrk, densely dotted, very thick] (Od.east) edge[bend left=60] (Oc.east);
        \draw[camdrk, densely dotted, very thick] plot [smooth, tension=1.5] coordinates { (Od.east) (dum2)
             (Oh.east)};
        \draw[camdrk, densely dotted, very thick] plot [smooth, tension=1.5] coordinates { (Od.east) (dum1)
             (Os.east)};
        \draw[camdrk, densely dotted, very thick] (Oc.east) edge[bend left=60] (Oh.east);
        \draw[camdrk, densely dotted, very thick] plot [smooth, tension=1.5] coordinates { (Oc.east) (dum3)
             (Os.east)};
        \draw[camdrk, densely dotted, very thick] (Oh.east) edge[bend left=60] (Os.east);

        \node[mymauve,rectangle, thick, align=center, draw, below left=3em and -4em of Os, text width=13.5
            em] (Q) {\texttt{"How many outlined objects are above the spade?"}};
        \node[mymauve,below=0em of Q] (ql) {\emph{query}};

        \path[mymauve,-stealth, dashed, thick] (Q.east) edge[bend right] (6.2, -0.7);

        \node[camdrk] at (6.7, 0) (RN){\textbf{\emph{RN}}};

\end{tikzpicture}
```

1.53 RN Object Extraction

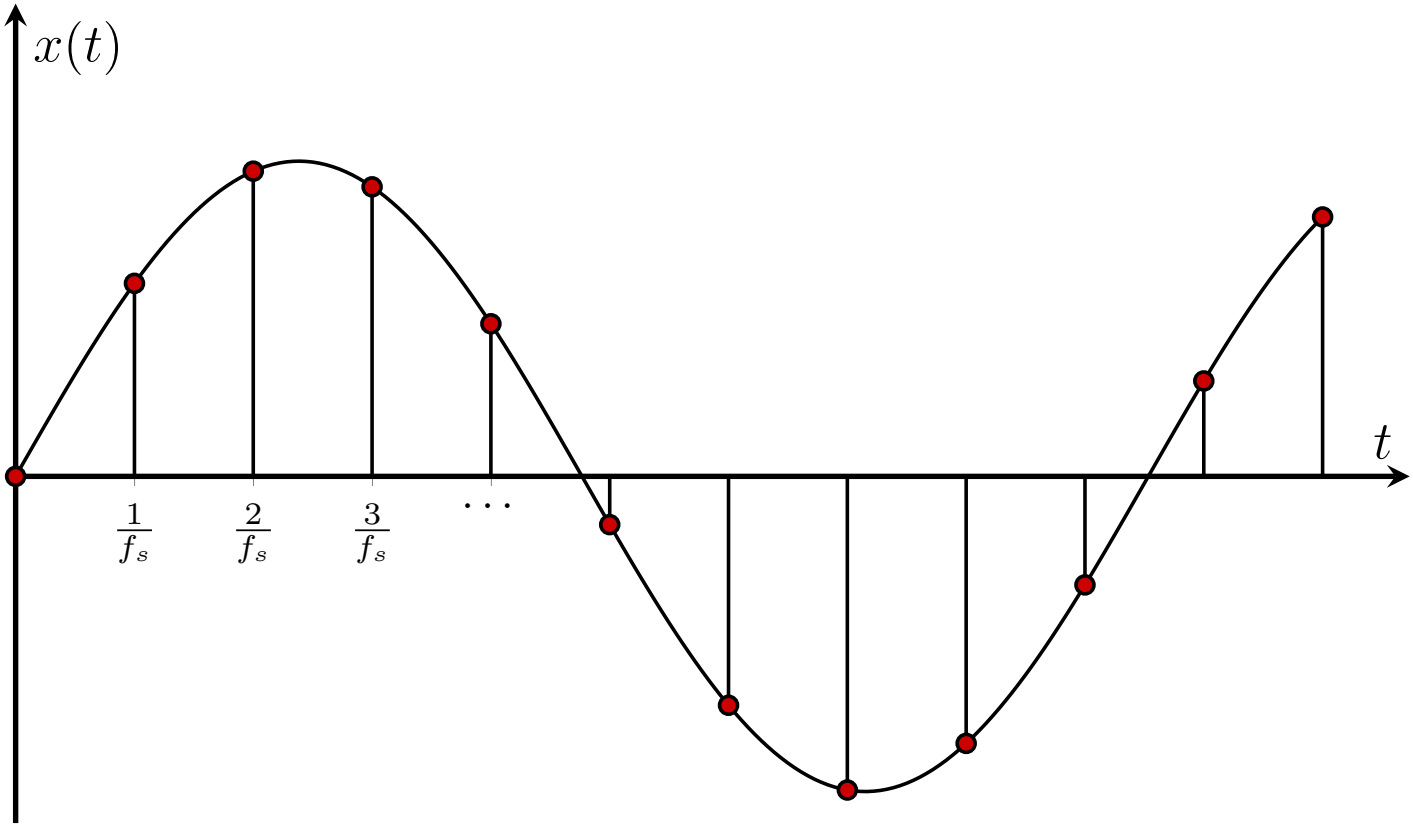



```
\definecolor{echoreg}{HTML}{2cb1e1}
\definecolor{olivegreen}{rgb}{0,0.6,0}
\definecolor{mymauve}{rgb}{0.58,0,0.82}
```

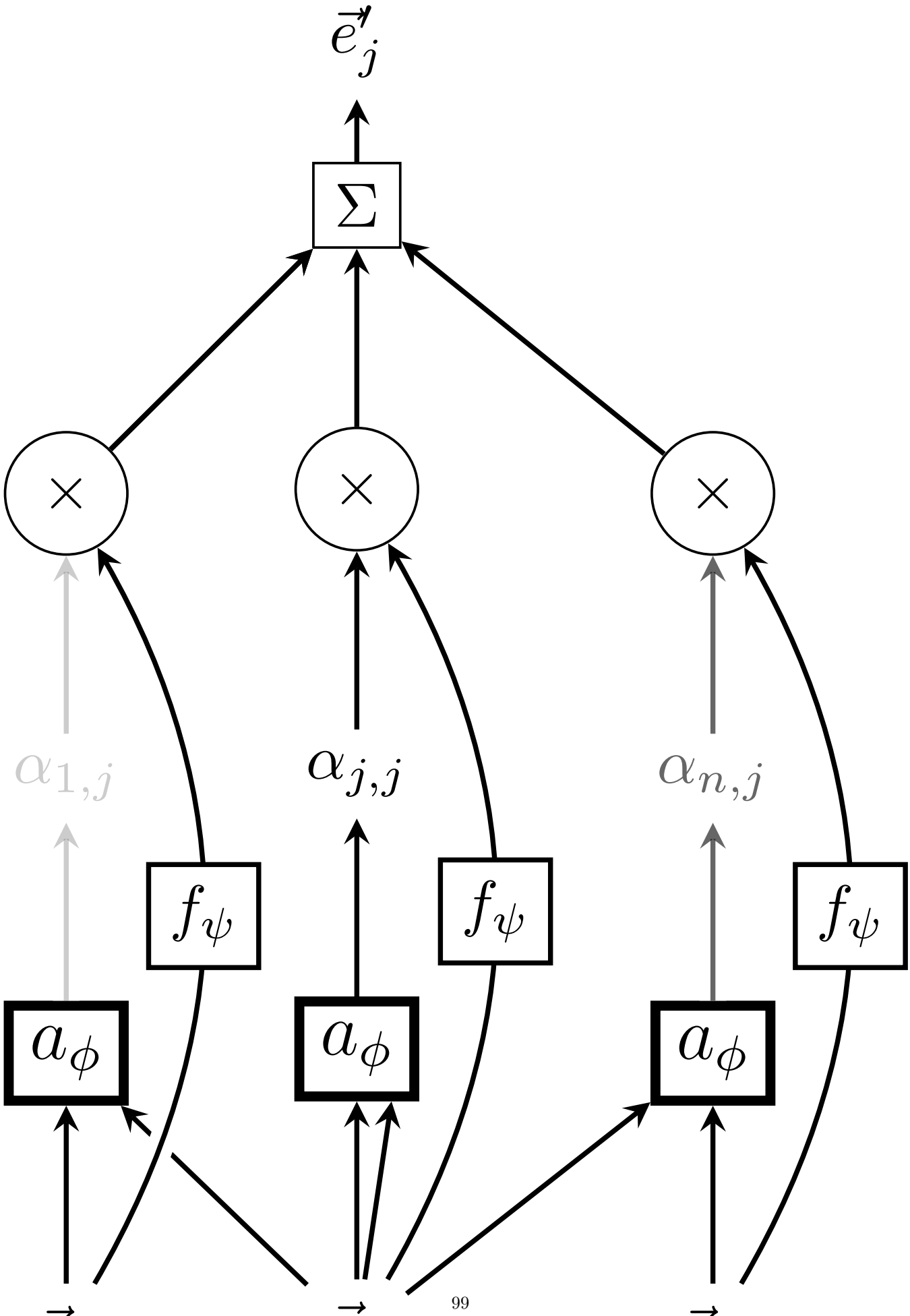
```
\newtoggle{redraw}
\newtoggle{redraw2}

\tikzset{%
pics/cube/.style args={#1/#2/#3/#4}{code={%
        \begin{scope}[line width=#4mm]
        \begin{scope}
        \clip (-#1,-#2,0) -- (#1,-#2,0) -- (#1,#2,0) -- (-#1,#2,0) -- cycle;
        \filldraw (-#1,-#2,0) -- (#1,-#2,0) -- (#1,#2,0) -- (-#1,#2,0) -- cycle;
        \end{scope}
\iftoggle{redraw}{%
}{%
        \begin{scope}
        \clip (-#1,-#2,0) -- (-#1-#3,-#2,-#3) -- (-#1-#3,#2,-#3) -- (-#1,#2,0) -- cycle;
        \filldraw (-#1,-#2,0) -- (-#1-#3,-#2,-#3) -- (-#1-#3,#2,-#3) -- (-#1,#2,0) -- cycle;
        \end{scope}
}
\iftoggle{redraw2}{%
}{
        \begin{scope}
        \clip (-#1,#2,0) -- (-#1-#3,#2,-#3) -- (#1-#3,#2,-#3) -- (#1,#2,0) -- cycle;
        \filldraw (-#1,#2,0) -- (-#1-#3,#2,-#3) -- (#1-#3,#2,-#3) -- (#1,#2,0) -- cycle;
        \end{scope}
}
        \node[inner sep=0] (-A) at (-#1-#3*0.5, 0, -#3*0.5) {};
        \node[inner sep=0] (-B) at (#1-#3*0.5, 0, -#3*0.5) {};

        \coordinate (-V) at (#1, #2);
        \coordinate (-W) at (#1, -#2);
        \end{scope}
}}}

\begin{tikzpicture}

        \node[] (i2) {};
        \pic[fill=green!50] (I2) {cube={1.8/1.8/0.4/1}};

        \togglefalse{redraw}
        \togglefalse{redraw2}

        \node[right=16em of i2] (y) {};

        \pic[right=16em of i2, fill=echoreg!50] (Y) {cube={1.8/1.8/1/1}};

        \node[right=12em of y] (y1) {};
        \pic[right=12em of y, fill=red!50] (Y1) {cube={0.9/0.9/1/1}};

        %transparent node to ease the arrow drawing
        \pic[right=12em of y1, draw=echoreg!0, fill=echoreg!0] (Y2) {cube={0.9/0.9/2/1}};
        \node[right=12em of y1] (y3) {};
        \pic[below right=1.1em and 13em of y1, fill=mymauve!30] (Y5) {cube={0.45/0.45/2/1}};
        \pic[below right=1.1em and 10em of y1, fill=mymauve!30] (Y6) {cube={0.45/0.45/2/1}};
        \pic[above right=1.1em and 13em of y1, fill=mymauve!30] (Y4) {cube={0.45/0.45/2/1}};
        \pic[above right=1.1em and 10em of y1, fill=mymauve!30] (Y3) {cube={0.45/0.45/2/1}};

        \draw [-stealth, ultra thick] (I2-B) -- node[above] {Conv.} (Y-A);

        \draw [-stealth, ultra thick] (Y-B) -- node[above] {Pool} (Y1-A);

        \draw [-stealth, ultra thick] (Y1-B) -- node[above=0.3em, inner sep=0.1em, xshift=-1em] {Conv.} (Y
            2-A);


        \color{black}

        \toggletrue{redraw}
        \toggletrue{redraw2}

        \pic[right=16em of i2, fill=echoreg!50] (Y) {cube={1.8/1.8/1/1}};

        \pic[right=12em of y, fill=red!50] (Y1) {cube={0.9/0.9/1/1}};

        \node[] (i2) {\LARGE ${\bf input}$};
        \node[above right=0.1em and 9em of y1] (z2) {\LARGE $\vec{o}_1$};
        \node[below right=0em and 9em of y1] (z2) {\LARGE $\vec{o}_3$};
```

```
        \node[above right=0.1em and 12em of y1] (z2) {\LARGE $\vec{o}_2$};
        \node[below right=0em and 12em of y1] (z2) {\LARGE $\vec{o}_4$};

\end{tikzpicture}
```

1.54 Sampling

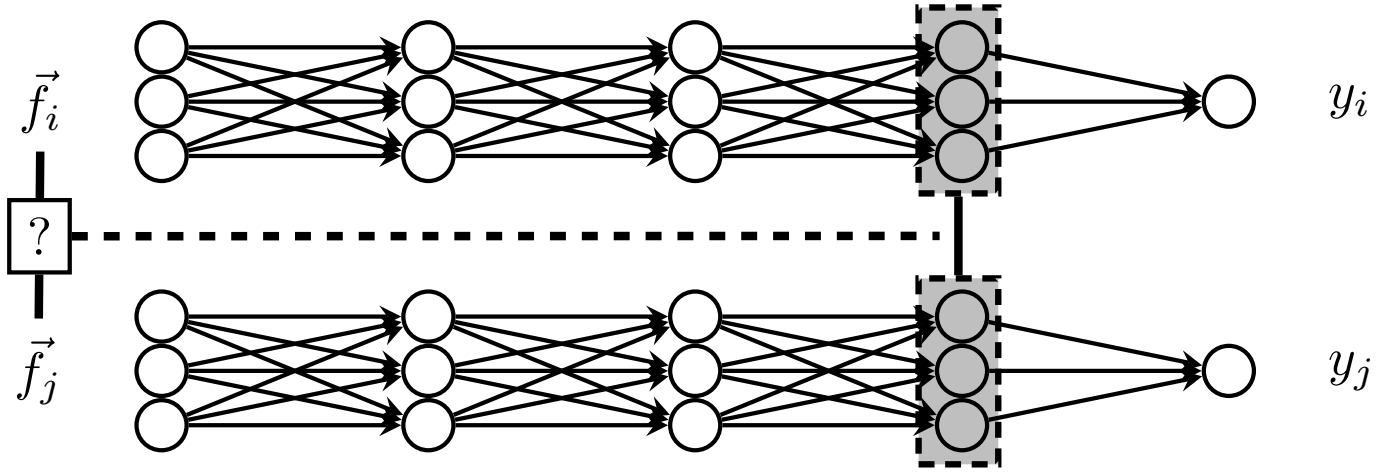



```
\begin{tikzpicture}
        \begin{axis}[
                width=12.5cm, height=8cm,
                xtick=\empty,
                ytick=\empty,
                xlabel={\large $t$},
                ylabel={\large $x(t)$},
                xmin=0, xmax=16,
                ymin=-1.1, ymax=1.5,
                xtick={1.365,  2.73, 4.095, 5.46},
                xticklabels={$\frac{1}{f_s}$, $\frac{2}{f_s}$, $\frac{3}{f_s}$, $\dots$},
                axis lines = middle,
                very thick,
                domain = 0:15
        ]
                \addplot[no markers, samples = 100, smooth ,thick] {sin(2*180*x/13)};
                \addplot+[ycomb, mark=*, mark color=blue, samples= 12, black, thick] {sin(2*180*x/13)};
        \end{axis}
\end{tikzpicture}
```


$\vec{e}'_j$
Σ
$\times$
$\times$
$\times$
$\alpha_{1,j}$
$\alpha_{j,j}$
$\alpha_{n,j}$
f_ψ
f_ψ
f_ψ
a_ϕ
a_ϕ
a_ϕ
$\rightarrow$
$\rightarrow$
$\rightarrow$

```
\begin{tikzpicture}

        \node (X1) {$\vec{e}_{1}$};

        \node[rectangle, right= 0.5em of X1] (x_dots_1) {$\dots$};

        \node[right=0.5em of x_dots_1] (Xj) {$\vec{e}_{j}$};

        \node[rectangle, right= 1em of Xj] (x_dots_2) {$\dots$};

        \node[right=1em of x_dots_2] (Xn) {$\vec{e}_{n}$};

        \node[rectangle, draw, ultra thick, above=of X1] (attn1) {\large $a_\phi$};

        \node[rectangle, draw, ultra thick, above=of Xj] (attnj) {\large $a_\phi$};

        \node[rectangle, draw, ultra thick, above=of Xn] (attnn) {\large $a_\phi$};


        \draw[-stealth, thick] (X1) -- (attn1);
        \draw[-stealth, thick] (Xj) -- (attn1);

        \draw[-stealth, thick] (Xj) -- (attnj);
        \draw[-stealth, thick] ([xshift=3em]Xj) -- (attnj);

        \draw[-stealth, thick] (Xj) -- (attnn);
        \draw[-stealth, thick] (Xn) -- (attnn);

        \node[above= of attn1, opacity=0.2] (alpha1j) {$\alpha_{1,j}$};
        \node[above= of attnj, opacity=1] (alphajj) {$\alpha_{j,j}$};
        \node[above= of attnn, opacity=0.6] (alphanj) {$\alpha_{n,j}$};

        \node[circle, draw, above=of alpha1j] (times1) {$\times$};
        \node[circle, draw, above=of alphajj] (timesj) {$\times$};
        \node[circle, draw, above=of alphanj] (timesn) {$\times$};

        \node[rectangle, draw, above=of timesj] (sum) {$\Sigma$};

        \node[above=1em of sum] (x_tprim) {$\vec{e}_j'$};

        \draw[-stealth, line width=1.5mm, white] (attn1) -- (alpha1j);
        \draw[-stealth, thick, opacity=0.2] (attn1) -- (alpha1j);
        \draw[-stealth, line width=1.5mm, white] (attnj) -- (alphajj);
        \draw[-stealth, thick, opacity=1] (attnj) -- (alphajj);
        \draw[-stealth, line width=1.5mm, white] (attnn) -- (alphanj);
        \draw[-stealth, thick, opacity=0.6] (attnn) -- (alphanj);

        \draw[-stealth, white, line width=1.5mm] (X1) edge[bend right=30] (times1);
        \draw[-stealth, thick] (X1) edge[bend right=30] node[rectangle, draw, fill=white, midway] {$f_\psi
            $} (times1);
        \draw[-stealth, white, line width=1.5mm] (Xj) edge[bend right=30] (timesj);
        \draw[-stealth, thick] (Xj) edge[bend right=30] node[rectangle, draw, fill=white, midway] {$f_\psi
            $} (timesj);
        \draw[-stealth, thick] (Xn) edge[bend right=30] node[rectangle, draw, fill=white, midway] {$f_\psi
            $} (timesn);

        \draw[-, line width=1.5mm, white] (times1) -- (sum);
        \draw[-stealth, thick] (times1) -- (sum);
        \draw[-, line width=1.5mm, white] (timesj) -- (sum);
        \draw[-stealth, thick] (timesj) -- (sum);
        \draw[-stealth, thick] (timesn) -- (sum);
        \draw[-stealth, thick] (times1) -- (sum);

        \draw[-stealth, line width=1.5mm, white] (alpha1j) -- (times1);
        \draw[-stealth, thick, opacity=0.2] (alpha1j) -- (times1);
        \draw[-stealth, line width=1.5mm, white] (alphajj) -- (timesj);
        \draw[-stealth, thick, opacity=1] (alphajj) -- (timesj);
        \draw[-stealth, line width=1.5mm, white] (alphanj) -- (timesn);
        \draw[-stealth, thick, opacity=0.6] (alphanj) -- (timesn);

        \draw[-stealth, thick] (sum) -- (x_tprim);

\end{tikzpicture}
```

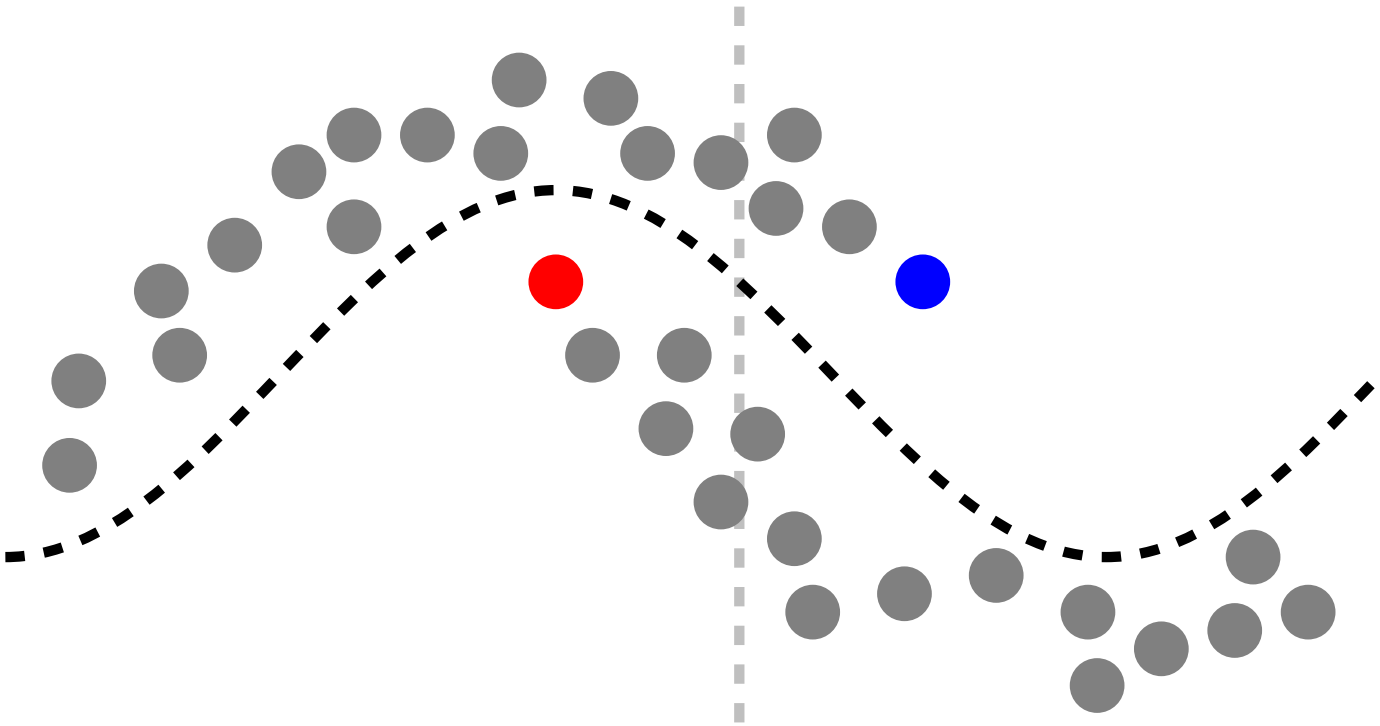
1.56 Semi-supervised Embedding




```
\begin{tikzpicture}
        \node[very thick, densely dashed, draw=black,rectangle, minimum height=3.5em, minimum width=1.5em,
            xshift=15em, yshift=-1em, fill=lightgray] (rekt1) {};

        \node[very thick, densely dashed, draw=black,rectangle, minimum height=3.5em, minimum width=1.5em,
            xshift=15em, yshift=-6.1em, fill=lightgray] (rekt2) {};

        \draw[ultra thick] (rekt1) -- (rekt2);

        \node[] (c) at ($(rekt1)!0.5!(rekt2)$) {};

        \node[circle, draw, thick] (f11) {};
        \node[circle, draw, thick, below=0em of f11] (f12) {};
        \node[circle, draw, thick, below=0em of f12] (f13) {};
        \node[circle, draw, thick, below=2em of f13] (f21) {};
        \node[circle, draw, thick, below=0em of f21] (f22) {};
        \node[circle, draw, thick, below=0em of f22] (f23) {};

        \node[left=1em of f12] (il1) {$\vec{f}_i$};
        \node[left=1em of f22] (il2) {$\vec{f}_j$};

        \node[rectangle, draw, thick] (Q) at ($(il1)!0.5!(il2)$) {?};
        \draw[ultra thick] (il1) -- (Q);
        \draw[ultra thick] (il2) -- (Q);

        \draw[dashed, ultra thick] (Q) -- (c);

        \node[circle, draw, thick, right=4em of f11] (h11) {};
        \node[circle, draw, thick, right=4em of f12] (h12) {};
        \node[circle, draw, thick, right=4em of f13] (h13) {};
        \node[circle, draw, thick, right=4em of f21] (h21) {};
        \node[circle, draw, thick, right=4em of f22] (h22) {};
        \node[circle, draw, thick, right=4em of f23] (h23) {};

        \node[circle, draw, thick, right=4em of h11] (k11) {};
        \node[circle, draw, thick, right=4em of h12] (k12) {};
        \node[circle, draw, thick, right=4em of h13] (k13) {};
        \node[circle, draw, thick, right=4em of h21] (k21) {};
        \node[circle, draw, thick, right=4em of h22] (k22) {};
        \node[circle, draw, thick, right=4em of h23] (k23) {};

        \node[circle, draw, thick, right=4em of k11] (l11) {};
        \node[circle, draw, thick, right=4em of k12] (l12) {};
        \node[circle, draw, thick, right=4em of k13] (l13) {};
        \node[circle, draw, thick, right=4em of k21] (l21) {};
        \node[circle, draw, thick, right=4em of k22] (l22) {};
        \node[circle, draw, thick, right=4em of k23] (l23) {};

        \node[circle, draw, thick, right=4em of l12] (o1) {};
        \node[circle, draw, thick, right=4em of l22] (o2) {};
        \node[right=1em of o1] (ll1) {$y_i$};
        \node[right=1em of o2] (ll2) {$y_j$};

        \foreach \l in {1,2}
```

```
                \foreach \x in {1,2,3}
                        \foreach \y in {1,2,3}
                                \draw[-stealth, thick] (f\l\x) -- (h\l\y);

        \foreach \l in {1,2}
                \foreach \x in {1,2,3}
                        \foreach \y in {1,2,3}
                                \draw[-stealth, thick] (h\l\x) -- (k\l\y);

        \foreach \l in {1,2}
                \foreach \x in {1,2,3}
                        \foreach \y in {1,2,3}
                                \draw[-stealth, thick] (k\l\x) -- (l\l\y);

        \foreach \l in {1,2}
                \foreach \x in {1,2,3}
                        \draw[-stealth, thick] (l\l\x) -- (o\l);

\end{tikzpicture}
```

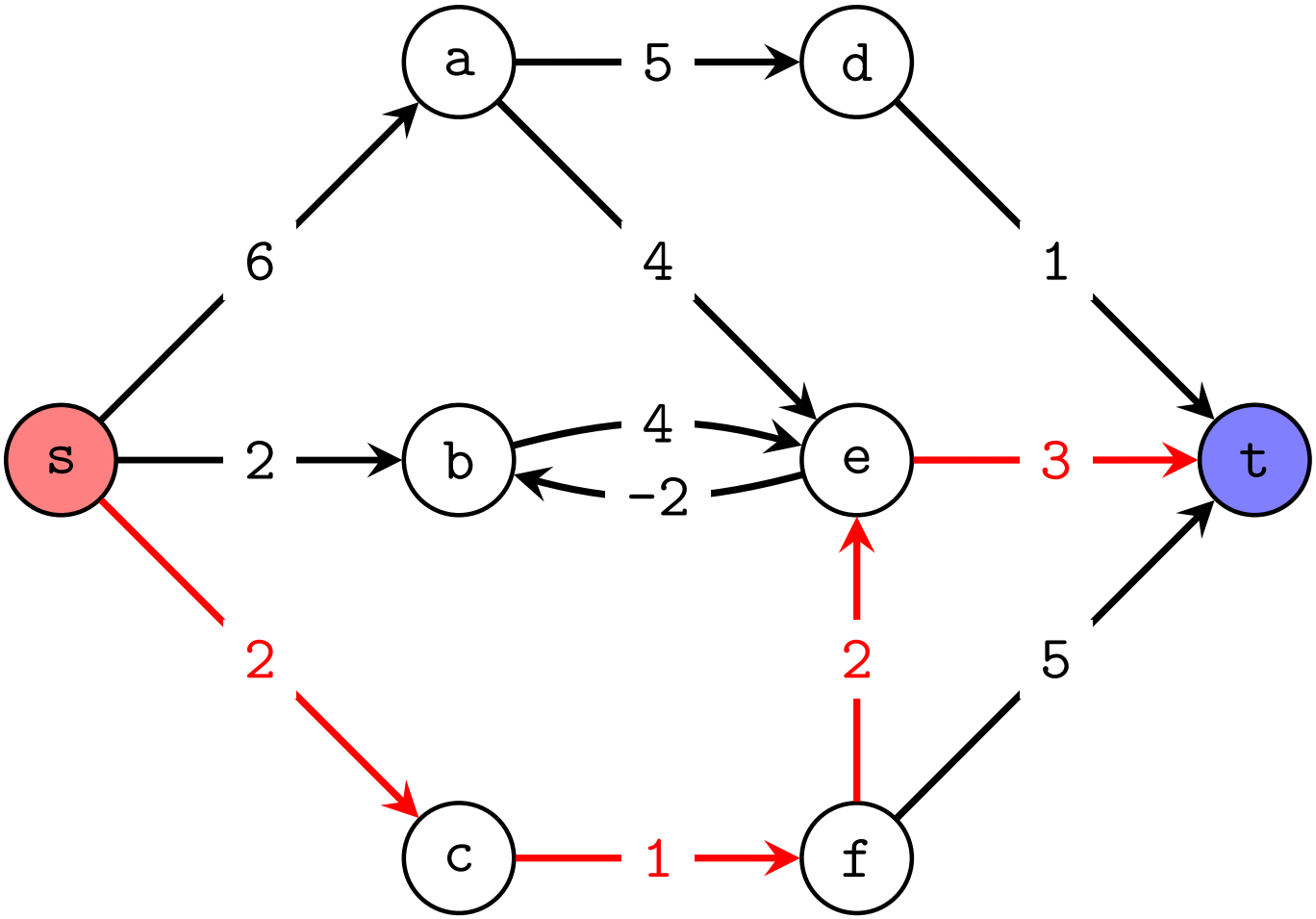
1.57 Semi-supervised Learning



```
\begin{tikzpicture}

        \draw[ultra thick, lightgray, dashed] (5.5, 2) -- (5.5, -2);
        \node[circle,inner sep=0.3em,fill=red,very thick] (X) at (4.5, 0.5) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (4.7, 0.1) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5.2, 0.1) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5.1, -0.3) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5.6, -0.33) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5.4, -0.7) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5.8, -0.9) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5.9, -1.3) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (6.4, -1.2) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (6.9, -1.1) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (7.4, -1.3) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (7.45, -1.7) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (7.8, -1.5) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (8.2, -1.4) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (8.3, -1.0) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (8.6, -1.3) {};

        \node[circle,inner sep=0.3em,fill=blue,very thick] (Y) at (6.5, 0.5) {};
```

```
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (6.1, 0.8) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5.7, 0.9) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5.8, 1.3) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5.4, 1.15) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (5, 1.2) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (4.8, 1.5) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (4.3, 1.6) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (4.2, 1.2) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (3.8, 1.3) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (3.4, 1.3) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (3.4, 0.8) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (3.1, 1.1) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (2.75, 0.7) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (2.45, 0.1) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (2.35, 0.45) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (1.9, -0.04) {};
        \node[circle,inner sep=0.3em,fill=gray,very thick] (Y) at (1.85, -0.5) {};

        \draw[ultra thick, black, dashed](1.5,-1) cos
    (3,0) sin (4.5,1) cos (6,0) sin (7.5,-1) cos (9,0);

\end{tikzpicture}
```

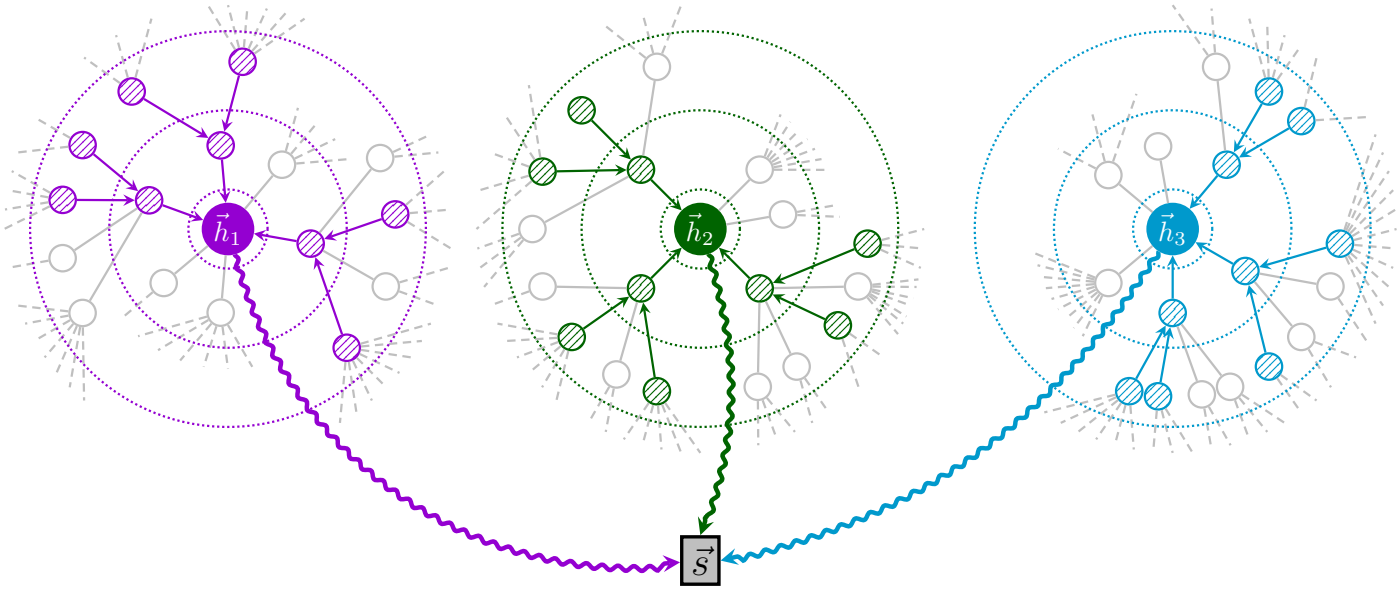
1.58 Shortest Path Problem




```
\begin{tikzpicture}[scale=0.8,every node/.style={scale=0.7},font=\tt]
        \SetUpEdge[     lw         = 0.75pt,
                        color      = red,
                        labelcolor = white]
        \GraphInit[vstyle=Normal]
        \SetGraphUnit{2}
        \tikzset{VertexStyle/.append  style={fill=red!50}}
        \Vertex{s}
        \tikzset{VertexStyle/.append  style={fill=white}}
        \NOEA(s){a}
        \EA(a){d}
```

```
        \tikzset{VertexStyle/.append  style={fill=blue!50}}
        \SOEA(d){t}
        \tikzset{VertexStyle/.append  style={fill=white}}
        \EA(s){b}
        \EA(b){e}
        \SOEA(s){c}
        \EA(c){f}
        \tikzset{EdgeStyle/.style={-stealth, color=black}}
        \Edge[label=6](s)(a)
        \Edge[label=2](s)(b)
        \SetUpEdge[labeltext=red]
        \tikzset{EdgeStyle/.style={-stealth, color=red}}
        \Edge[label=2](s)(c)
        \SetUpEdge[labeltext=black]
        \tikzset{EdgeStyle/.style={-stealth, color=black}}
        \Edge[label=5](a)(d)
        \Edge[label=4](a)(e)
        \tikzset{EdgeStyle/.style={-stealth, color=black, bend left=15}}
        \Edge[label=4](b)(e)
        \Edge[label=-2](e)(b)
        \SetUpEdge[labeltext=red]
        \tikzset{EdgeStyle/.style={-stealth, color=red}}
        \Edge[label=1](c)(f)
        \SetUpEdge[labeltext=black]
        \tikzset{EdgeStyle/.style={-stealth, color=black}}
        \Edge[label=1](d)(t)
        \SetUpEdge[labeltext=red]
        \tikzset{EdgeStyle/.style={-stealth, color=red}}
        \Edge[label=3](e)(t)
        \Edge[label=2](f)(e)
        \SetUpEdge[labeltext=black]
        \tikzset{EdgeStyle/.style={-stealth, color=black}}
        \Edge[label=5](f)(t)
\end{tikzpicture}
```

1.59 Sparse DGI




```
\definecolor{mygreen}{HTML}{006400}
\definecolor{mymauve}{rgb}{0.58,0,0.82}
\definecolor{echodrk}{HTML}{0099cc}

\begin{tikzpicture}
        \node[circle, fill=mymauve, draw=mymauve, inner sep=0.1em, thick] (h1) {\textcolor{white}{$\vec{h
            }_1$}};
        \node[circle, draw=lightgray, thick] (000) at ([shift=({50:3 em})]h1) {};
        \node[circle, draw=mymauve, pattern=north east lines,  pattern color=mymauve, thick] (001) at ([
            shift=({95:3 em})]h1) {};
        \node[circle, draw=mymauve, pattern=north east lines, pattern color=mymauve, thick] (002) at ([
            shift=({160:3 em})]h1) {};
```

```
        \node[circle, draw=lightgray, thick] (003) at ([shift=({220:3 em})]h1) {};
        \node[circle, draw=lightgray, thick] (004) at ([shift=({265:3 em})]h1) {};
        \node[circle, draw=mymauve, pattern=north east lines, pattern color=mymauve, thick] (005) at ([
            shift=({350:3 em})]h1) {};

        \node[circle, draw=mymauve, pattern=north east lines, pattern color=mymauve, thick] (010) at ([
            shift=({85:6 em})]h1) {};
        \node[circle, draw=mymauve, pattern=north east lines, pattern color=mymauve, thick] (011) at ([
            shift=({125:6 em})]h1) {};
        \node[circle, draw=mymauve, pattern=north east lines, pattern color=mymauve, thick] (012) at ([
            shift=({150:6 em})]h1) {};
        \node[circle, draw=mymauve, pattern=north east lines, pattern color=mymauve, thick] (013) at ([
            shift=({170:6 em})]h1) {};
        \node[circle, lightgray, draw, thick] (014) at ([shift=({190:6 em})]h1) {};
        \node[circle, lightgray,draw, thick] (015) at ([shift=({210:6 em})]h1) {};
        \node[circle, draw=mymauve, pattern=north east lines, pattern color=mymauve, thick] (016) at ([
            shift=({315:6 em})]h1) {};
        \node[circle, lightgray,draw, thick] (017) at ([shift=({340:6 em})]h1) {};
        \node[circle, draw=mymauve, pattern=north east lines, pattern color=mymauve, thick] (018) at ([
            shift=({365:6 em})]h1) {};
        \node[circle,lightgray, draw, thick] (019) at ([shift=({385:6 em})]h1) {};

        \draw[-, thick, lightgray] (h1) -- (000);
        \draw[stealth-, thick, mymauve] (h1) -- (001);
        \draw[stealth-, thick, mymauve] (h1) -- (002);
        \draw[-, thick, lightgray] (h1) -- (003);
        \draw[-, thick, lightgray] (h1) -- (004);
        \draw[stealth-, thick, mymauve] (h1) -- (005);

        \draw[stealth-, thick, mymauve] (001) -- (010);
        \draw[stealth-, thick, mymauve] (001) -- (011);
        \draw[stealth-, thick, mymauve] (002) -- (012);
        \draw[stealth-, thick, mymauve] (002) -- (013);
        \draw[-, thick, lightgray] (002) -- (014);
        \draw[-, thick, lightgray] (002) -- (015);
        \draw[stealth-, thick, mymauve] (005) -- (016);
        \draw[-, thick, lightgray] (005) -- (017);
        \draw[stealth-, thick, mymauve] (005) -- (018);
        \draw[-, thick, lightgray] (005) -- (019);

        \draw[-, densely dashed, lightgray, thick] (000) -- ($(h1) + ({30:5 em})$);
        \draw[-, densely dashed, lightgray, thick] (000) -- ($(h1) + ({40:5 em})$);
        \draw[-, densely dashed, lightgray, thick] (000) -- ($(h1) + ({50:5 em})$);
        \draw[-, densely dashed, lightgray, thick] (000) -- ($(h1) + ({60:5 em})$);
        \draw[-, densely dashed, lightgray, thick] (003) -- ($(h1) + ({220:5 em})$);

        \draw[-, densely dashed, lightgray, thick] (004) -- ($(h1) + ({230:5 em})$);
        \draw[-, densely dashed, lightgray, thick] (004) -- ($(h1) + ({240:5 em})$);
        \draw[-, densely dashed, lightgray, thick] (004) -- ($(h1) + ({250:5 em})$);
        \draw[-, densely dashed, lightgray, thick] (004) -- ($(h1) + ({260:5 em})$);
        \draw[-, densely dashed, lightgray, thick] (004) -- ($(h1) + ({270:5 em})$);
        \draw[-, densely dashed, lightgray, thick] (004) -- ($(h1) + ({280:5 em})$);

        \draw[-, densely dashed, lightgray, thick] (010) -- ($(h1) + ({70:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (010) -- ($(h1) + ({75:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (010) -- ($(h1) + ({80:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (010) -- ($(h1) + ({85:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (010) -- ($(h1) + ({90:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (010) -- ($(h1) + ({95:8 em})$);

        \draw[-, densely dashed, lightgray, thick] (011) -- ($(h1) + ({110:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (011) -- ($(h1) + ({120:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (011) -- ($(h1) + ({130:8 em})$);

        \draw[-, densely dashed, lightgray, thick] (012) -- ($(h1) + ({150:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (012) -- ($(h1) + ({160:8 em})$);

        \draw[-, densely dashed, lightgray, thick] (013) -- ($(h1) + ({165:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (013) -- ($(h1) + ({170:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (013) -- ($(h1) + ({175:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (013) -- ($(h1) + ({180:8 em})$);

        \draw[-, densely dashed, lightgray, thick] (014) -- ($(h1) + ({190:8 em})$);

        \draw[-, densely dashed, lightgray, thick] (015) -- ($(h1) + ({200:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (015) -- ($(h1) + ({205:8 em})$);
```

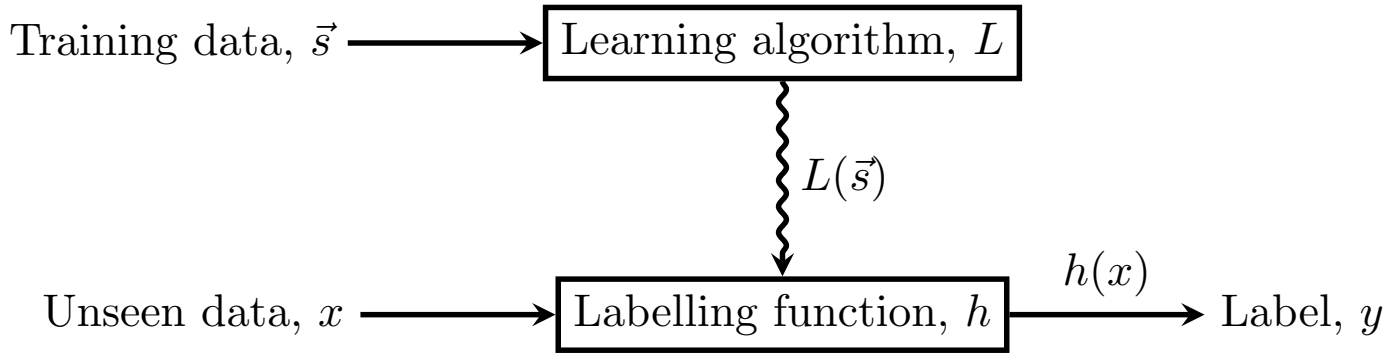
```
\draw[-, densely dashed, lightgray, thick] (015) -- ($(h1) + ({210:8 em})$);
\draw[-, densely dashed, lightgray, thick] (015) -- ($(h1) + ({215:8 em})$);
\draw[-, densely dashed, lightgray, thick] (015) -- ($(h1) + ({220:8 em})$);
\draw[-, densely dashed, lightgray, thick] (015) -- ($(h1) + ({225:8 em})$);
\draw[-, densely dashed, lightgray, thick] (015) -- ($(h1) + ({230:8 em})$);

\draw[-, densely dashed, lightgray, thick] (016) -- ($(h1) + ({300:8 em})$);
\draw[-, densely dashed, lightgray, thick] (016) -- ($(h1) + ({305:8 em})$);
\draw[-, densely dashed, lightgray, thick] (016) -- ($(h1) + ({310:8 em})$);
\draw[-, densely dashed, lightgray, thick] (016) -- ($(h1) + ({315:8 em})$);
\draw[-, densely dashed, lightgray, thick] (016) -- ($(h1) + ({320:8 em})$);
\draw[-, densely dashed, lightgray, thick] (016) -- ($(h1) + ({325:8 em})$);
\draw[-, densely dashed, lightgray, thick] (016) -- ($(h1) + ({330:8 em})$);
\draw[-, densely dashed, lightgray, thick] (016) -- ($(h1) + ({335:8 em})$);

\draw[-, densely dashed, lightgray, thick] (017) -- ($(h1) + ({340:8 em})$);
\draw[-, densely dashed, lightgray, thick] (017) -- ($(h1) + ({350:8 em})$);

\draw[-, densely dashed, lightgray, thick] (018) -- ($(h1) + ({355:8 em})$);
\draw[-, densely dashed, lightgray, thick] (018) -- ($(h1) + ({365:8 em})$);
\draw[-, densely dashed, lightgray, thick] (018) -- ($(h1) + ({375:8 em})$);

\draw[-, densely dashed, lightgray, thick] (019) -- ($(h1) + ({380:8 em})$);
\draw[-, densely dashed, lightgray, thick] (019) -- ($(h1) + ({385:8 em})$);

\node[circle, draw, densely dotted, mymauve, thick, inner sep=1em] at (h1) {};
\node[circle, draw, densely dotted, mymauve, thick, inner sep=3em] at (h1) {};
\node[circle, draw, densely dotted, mymauve, thick, inner sep=5em] at (h1) {};

\node[circle, fill=mygreen, draw=mygreen, inner sep=0.1em, thick, right=15em of h1] (h2) {\
    textcolor{white}{$\vec{h}_2$}};
\node[circle, lightgray, draw, thick] (100) at ([shift=({10:3 em})]h2) {};
\node[circle, lightgray, draw, thick] (101) at ([shift=({45:3 em})]h2) {};
\node[circle, draw=mygreen, pattern=north east lines, pattern color=mygreen, thick] (102) at ([
    shift=({135:3 em})]h2) {};
\node[circle, draw=mygreen, pattern=north east lines, pattern color=mygreen, thick] (103) at ([
    shift=({225:3 em})]h2) {};
\node[circle, draw=mygreen, pattern=north east lines, pattern color=mygreen, thick] (104) at ([
    shift=({315:3 em})]h2) {};
\node[circle,lightgray, draw, thick] (110) at ([shift=({105:6 em})]h2) {};
\node[circle, draw=mygreen, pattern=north east lines, pattern color=mygreen, thick] (111) at ([
    shift=({135:6 em})]h2) {};
\node[circle, draw=mygreen, pattern=north east lines, pattern color=mygreen, thick] (112) at ([
    shift=({160:6 em})]h2) {};
\node[circle,lightgray, draw, thick] (113) at ([shift=({180:6 em})]h2) {};
\node[circle,lightgray, draw, thick] (114) at ([shift=({200:6 em})]h2) {};
\node[circle, draw=mygreen, pattern=north east lines, pattern color=mygreen, thick] (115) at ([
    shift=({220:6 em})]h2) {};
\node[circle,lightgray, draw, thick] (116) at ([shift=({240:6 em})]h2) {};
\node[circle, draw=mygreen, pattern=north east lines, pattern color=mygreen, thick] (117) at ([
    shift=({255:6 em})]h2) {};
\node[circle,lightgray, draw, thick] (118) at ([shift=({290:6 em})]h2) {};
\node[circle,lightgray, draw, thick] (119) at ([shift=({305:6 em})]h2) {};
\node[circle, draw=mygreen, pattern=north east lines, pattern color=mygreen, thick] (1110) at ([
    shift=({325:6 em})]h2) {};
\node[circle,lightgray, draw, thick] (1111) at ([shift=({340:6 em})]h2) {};
\node[circle, draw=mygreen, pattern=north east lines, pattern color=mygreen, thick] (1112) at ([
    shift=({355:6 em})]h2) {};

\draw[-, thick, lightgray] (h2) -- (100);
\draw[-, thick, lightgray] (h2) -- (101);
\draw[stealth-, thick, mygreen] (h2) -- (102);
\draw[stealth-, thick, mygreen] (h2) -- (103);
\draw[stealth-, thick, mygreen] (h2) -- (104);

\draw[-, thick, lightgray] (102) -- (110);
\draw[stealth-, thick, mygreen] (102) -- (111);
\draw[stealth-, thick, mygreen] (102) -- (112);
\draw[-, thick, lightgray] (102) -- (113);
\draw[-, thick, lightgray] (103) -- (114);
\draw[stealth-, thick, mygreen] (103) -- (115);
\draw[-, thick, lightgray] (103) -- (116);
\draw[stealth-, thick, mygreen] (103) -- (117);
\draw[-, thick, lightgray] (104) -- (118);
\draw[-, thick, lightgray] (104) -- (119);
\draw[stealth-, thick, mygreen] (104) -- (1110);
```

```
\draw[-, thick, lightgray] (104) -- (1111);
\draw[stealth-, thick, mygreen] (104) -- (1112);


\draw[-, densely dashed, lightgray, thick] (100) -- ($(h2) + ({5:5 em})$);
\draw[-, densely dashed, lightgray, thick] (100) -- ($(h2) + ({10:5 em})$);
\draw[-, densely dashed, lightgray, thick] (101) -- ($(h2) + ({25:5 em})$);
\draw[-, densely dashed, lightgray, thick] (101) -- ($(h2) + ({30:5 em})$);
\draw[-, densely dashed, lightgray, thick] (101) -- ($(h2) + ({35:5 em})$);
\draw[-, densely dashed, lightgray, thick] (101) -- ($(h2) + ({40:5 em})$);
\draw[-, densely dashed, lightgray, thick] (101) -- ($(h2) + ({45:5 em})$);
\draw[-, densely dashed, lightgray, thick] (101) -- ($(h2) + ({50:5 em})$);
\draw[-, densely dashed, lightgray, thick] (101) -- ($(h2) + ({55:5 em})$);


\draw[-, densely dashed, lightgray, thick] (110) -- ($(h2) + ({95:8 em})$);
\draw[-, densely dashed, lightgray, thick] (110) -- ($(h2) + ({105:8 em})$);
\draw[-, densely dashed, lightgray, thick] (110) -- ($(h2) + ({115:8 em})$);

\draw[-, densely dashed, lightgray, thick] (112) -- ($(h2) + ({140:8 em})$);
\draw[-, densely dashed, lightgray, thick] (112) -- ($(h2) + ({150:8 em})$);
\draw[-, densely dashed, lightgray, thick] (112) -- ($(h2) + ({160:8 em})$);
\draw[-, densely dashed, lightgray, thick] (112) -- ($(h2) + ({170:8 em})$);
\draw[-, densely dashed, lightgray, thick] (112) -- ($(h2) + ({180:8 em})$);

\draw[-, densely dashed, lightgray, thick] (113) -- ($(h2) + ({185:8 em})$);
\draw[-, densely dashed, lightgray, thick] (113) -- ($(h2) + ({190:8 em})$);
\draw[-, densely dashed, lightgray, thick] (113) -- ($(h2) + ({195:8 em})$);

\draw[-, densely dashed, lightgray, thick] (114) -- ($(h2) + ({200:8 em})$);

\draw[-, densely dashed, lightgray, thick] (115) -- ($(h2) + ({205:8 em})$);
\draw[-, densely dashed, lightgray, thick] (115) -- ($(h2) + ({210:8 em})$);
\draw[-, densely dashed, lightgray, thick] (115) -- ($(h2) + ({215:8 em})$);
\draw[-, densely dashed, lightgray, thick] (115) -- ($(h2) + ({220:8 em})$);
\draw[-, densely dashed, lightgray, thick] (115) -- ($(h2) + ({225:8 em})$);
\draw[-, densely dashed, lightgray, thick] (115) -- ($(h2) + ({230:8 em})$);
\draw[-, densely dashed, lightgray, thick] (116) -- ($(h2) + ({240:8 em})$);
\draw[-, densely dashed, lightgray, thick] (116) -- ($(h2) + ({245:8 em})$);

\draw[-, densely dashed, lightgray, thick] (117) -- ($(h2) + ({250:8 em})$);
\draw[-, densely dashed, lightgray, thick] (117) -- ($(h2) + ({255:8 em})$);
\draw[-, densely dashed, lightgray, thick] (117) -- ($(h2) + ({260:8 em})$);
\draw[-, densely dashed, lightgray, thick] (117) -- ($(h2) + ({265:8 em})$);
\draw[-, densely dashed, lightgray, thick] (117) -- ($(h2) + ({270:8 em})$);


\draw[-, densely dashed, lightgray, thick] (118) -- ($(h2) + ({285:8 em})$);
\draw[-, densely dashed, lightgray, thick] (118) -- ($(h2) + ({290:8 em})$);
\draw[-, densely dashed, lightgray, thick] (118) -- ($(h2) + ({295:8 em})$);

\draw[-, densely dashed, lightgray, thick] (119) -- ($(h2) + ({300:8 em})$);
\draw[-, densely dashed, lightgray, thick] (119) -- ($(h2) + ({305:8 em})$);

\draw[-, densely dashed, lightgray, thick] (1110) -- ($(h2) + ({315:8 em})$);
\draw[-, densely dashed, lightgray, thick] (1110) -- ($(h2) + ({325:8 em})$);

\draw[-, densely dashed, lightgray, thick] (1111) -- ($(h2) + ({332:8 em})$);
\draw[-, densely dashed, lightgray, thick] (1111) -- ($(h2) + ({335:8 em})$);
\draw[-, densely dashed, lightgray, thick] (1111) -- ($(h2) + ({337:8 em})$);
\draw[-, densely dashed, lightgray, thick] (1111) -- ($(h2) + ({340:8 em})$);
\draw[-, densely dashed, lightgray, thick] (1111) -- ($(h2) + ({342:8 em})$);
\draw[-, densely dashed, lightgray, thick] (1111) -- ($(h2) + ({345:8 em})$);
\draw[-, densely dashed, lightgray, thick] (1111) -- ($(h2) + ({347:8 em})$);

\draw[-, densely dashed, lightgray, thick] (1112) -- ($(h2) + ({350:8 em})$);
\draw[-, densely dashed, lightgray, thick] (1112) -- ($(h2) + ({355:8 em})$);
\draw[-, densely dashed, lightgray, thick] (1112) -- ($(h2) + ({360:8 em})$);

\node[circle, draw, densely dotted, mygreen, thick, inner sep=1em] at (h2) {};
\node[circle, draw, densely dotted, mygreen, thick, inner sep=3em] at (h2) {};
\node[circle, draw, densely dotted, mygreen, thick, inner sep=5em] at (h2) {};


\node[circle, fill=echodrk, draw=echodrk, inner sep=0.1em, thick, right=15em of h2] (h3) {\
    textcolor{white}{$\vec{h}_3$}};
```

```
\node[circle, draw=echodrk, pattern=north east lines, pattern color=echodrk, thick] (200) at ([
    shift={(50:3 em)}]h3) {};
\node[circle, draw=lightgray, thick] (201) at ([shift={(100:3 em)}]h3) {};
\node[circle, draw=lightgray, thick] (202) at ([shift={(140:3 em)}]h3) {};
\node[circle, draw=lightgray, thick] (203) at ([shift={(220:3 em)}]h3) {};
\node[circle, draw=echodrk, pattern=north east lines, pattern color=echodrk, thick] (204) at ([
    shift={(270:3 em)}]h3) {};
\node[circle, draw=echodrk, pattern=north east lines, pattern color=echodrk, thick] (205) at ([
    shift={(330:3 em)}]h3) {};
\node[circle, draw=echodrk, pattern=north east lines, pattern color=echodrk, thick] (210) at ([
    shift={(40:6 em)}]h3) {};
\node[circle, draw=echodrk, pattern=north east lines, pattern color=echodrk, thick] (211) at ([
    shift={(55:6 em)}]h3) {};
\node[circle, draw=lightgray, thick] (212) at ([shift={(75:6 em)}]h3) {};
\node[circle, draw=echodrk, pattern=north east lines, pattern color=echodrk, thick] (213) at ([
    shift={(255:6 em)}]h3) {};
\node[circle, draw=echodrk, pattern=north east lines, pattern color=echodrk, thick] (214) at ([
    shift={(265:6 em)}]h3) {};
\node[circle, draw=lightgray, thick] (215) at ([shift={(280:6 em)}]h3) {};
\node[circle, draw=lightgray, thick] (216) at ([shift={(290:6 em)}]h3) {};
\node[circle, draw=echodrk, pattern=north east lines, pattern color=echodrk, thick] (217) at ([
    shift={(305:6 em)}]h3) {};
\node[circle, draw=lightgray, thick] (218) at ([shift={(320:6 em)}]h3) {};
\node[circle, draw=lightgray, thick] (219) at ([shift={(340:6 em)}]h3) {};
\node[circle, draw=echodrk, pattern=north east lines, pattern color=echodrk, thick] (2110) at ([
    shift={(355:6 em)}]h3) {};

\draw[stealth-, thick, echodrk] (h3) -- (200);
\draw[-, thick, lightgray] (h3) -- (201);
\draw[-, thick, lightgray] (h3) -- (202);
\draw[-, thick, lightgray] (h3) -- (203);
\draw[stealth-, thick, echodrk] (h3) -- (204);
\draw[stealth-, thick, echodrk] (h3) -- (205);

\draw[stealth-, thick, echodrk] (200) -- (210);
\draw[stealth-, thick, echodrk] (200) -- (211);
\draw[-, thick, lightgray] (200) -- (212);
\draw[stealth-, thick, echodrk] (204) -- (213);
\draw[stealth-, thick, echodrk] (204) -- (214);
\draw[-, thick, lightgray] (204) -- (215);
\draw[-, thick, lightgray] (204) -- (216);
\draw[stealth-, thick, echodrk] (205) -- (217);
\draw[-, thick, lightgray] (205) -- (218);
\draw[-, thick, lightgray] (205) -- (219);
\draw[stealth-, thick, echodrk] (205) -- (2110);



\draw[-, densely dashed, lightgray, thick] (202) -- ($(h3) + ({105:5 em})$);
\draw[-, densely dashed, lightgray, thick] (202) -- ($(h3) + ({125:5 em})$);
\draw[-, densely dashed, lightgray, thick] (202) -- ($(h3) + ({145:5 em})$);

\draw[-, densely dashed, lightgray, thick] (203) -- ($(h3) + ({190:5 em})$);
\draw[-, densely dashed, lightgray, thick] (203) -- ($(h3) + ({195:5 em})$);
\draw[-, densely dashed, lightgray, thick] (203) -- ($(h3) + ({200:5 em})$);
\draw[-, densely dashed, lightgray, thick] (203) -- ($(h3) + ({205:5 em})$);
\draw[-, densely dashed, lightgray, thick] (203) -- ($(h3) + ({210:5 em})$);
\draw[-, densely dashed, lightgray, thick] (203) -- ($(h3) + ({215:5 em})$);
\draw[-, densely dashed, lightgray, thick] (203) -- ($(h3) + ({220:5 em})$);
\draw[-, densely dashed, lightgray, thick] (203) -- ($(h3) + ({225:5 em})$);
\draw[-, densely dashed, lightgray, thick] (203) -- ($(h3) + ({230:5 em})$);

\draw[-, densely dashed, lightgray, thick] (210) -- ($(h3) + ({30:8 em})$);
\draw[-, densely dashed, lightgray, thick] (210) -- ($(h3) + ({50:8 em})$);
\draw[-, densely dashed, lightgray, thick] (211) -- ($(h3) + ({55:8 em})$);
\draw[-, densely dashed, lightgray, thick] (211) -- ($(h3) + ({60:8 em})$);
\draw[-, densely dashed, lightgray, thick] (211) -- ($(h3) + ({65:8 em})$);
\draw[-, densely dashed, lightgray, thick] (211) -- ($(h3) + ({70:8 em})$);
\draw[-, densely dashed, lightgray, thick] (212) -- ($(h3) + ({80:8 em})$);
\draw[-, densely dashed, lightgray, thick] (212) -- ($(h3) + ({90:8 em})$);

\draw[-, densely dashed, lightgray, thick] (213) -- ($(h3) + ({235:8 em})$);
\draw[-, densely dashed, lightgray, thick] (213) -- ($(h3) + ({240:8 em})$);
\draw[-, densely dashed, lightgray, thick] (213) -- ($(h3) + ({245:8 em})$);
\draw[-, densely dashed, lightgray, thick] (213) -- ($(h3) + ({250:8 em})$);
\draw[-, densely dashed, lightgray, thick] (213) -- ($(h3) + ({255:8 em})$);
```

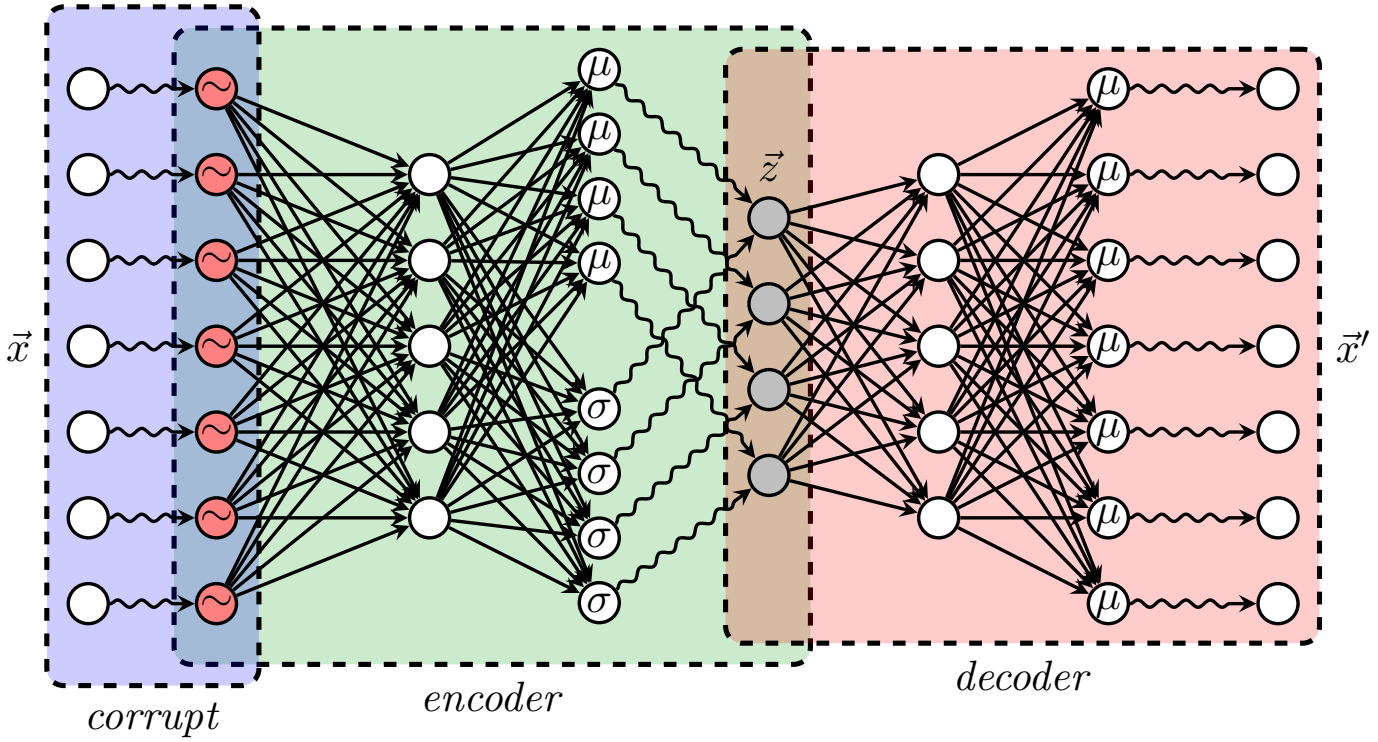
```
        \draw[-, densely dashed, lightgray, thick] (213) -- ($(h3) + ({260:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (214) -- ($(h3) + ({265:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (214) -- ($(h3) + ({270:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (214) -- ($(h3) + ({275:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (215) -- ($(h3) + ({280:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (215) -- ($(h3) + ({285:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (216) -- ($(h3) + ({290:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (216) -- ($(h3) + ({295:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (216) -- ($(h3) + ({300:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (217) -- ($(h3) + ({305:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (217) -- ($(h3) + ({310:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (218) -- ($(h3) + ({315:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (218) -- ($(h3) + ({325:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (219) -- ($(h3) + ({330:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({335:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({340:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({345:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({350:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({355:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({360:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({365:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({370:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({375:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({380:8 em})$);
        \draw[-, densely dashed, lightgray, thick] (2110) -- ($(h3) + ({385:8 em})$);

        \node[circle, draw, densely dotted, echodrk, thick, inner sep=1em] at (h3) {};
        \node[circle, draw, densely dotted, echodrk, thick, inner sep=3em] at (h3) {};
        \node[circle, draw, densely dotted, echodrk, thick, inner sep=5em] at (h3) {};


        \node[rectangle, below=10em of h2, fill=lightgray, draw=black, very thick] (s) {\Large $\vec{s}$};

        \draw[-stealth,  mymauve, ultra thick] (h1) edge[bend right=40, decoration={snake, pre length=0.01
            mm, segment length=2mm, amplitude=0.3mm, post length=1.5mm}, decorate] (s);
        \draw[-stealth,  mygreen, ultra thick] (h2) edge[bend left=18, decoration={snake, pre length=0.01mm
            , segment length=2mm, amplitude=0.3mm, post length=1.5mm}, decorate] (s.north);
        \draw[-stealth,  echodrk, ultra thick] (h3) edge[bend left=22, decoration={snake, pre length=0.01mm
            , segment length=2mm, amplitude=0.3mm, post length=1.5mm}, decorate] (s.east);

\end{tikzpicture}
```

1.60 Supervised Learning Setup




```
\begin{tikzpicture}[node distance=1.5cm]
        \node[rectangle, very thick, draw] (learning) {Learning algorithm, $L$};
        \node[rectangle, very thick, draw, below = of learning] (inference) {Labelling function, $h$};
        \node[left = of learning] (train) {Training data, $\vec{s}$};
        \node[left = of inference] (uns) {Unseen data, $x$};
        \node[right = of inference] (lab) {Label, $y$};

        \draw[-stealth, very thick] (train) -- (learning);
        \draw[-stealth, very thick, decoration={snake, segment length=2mm, amplitude=0.3mm, post length=1.5
            mm}, decorate] (learning) -- node[right] {$L(\vec{s})$} (inference);
        \draw[-stealth, very thick] (uns) -- (inference);
        \draw[-stealth, very thick] (inference) -- node[above] {$h(x)$} (lab);
\end{tikzpicture}
```

1.61 Variational Denoising Autoencoder

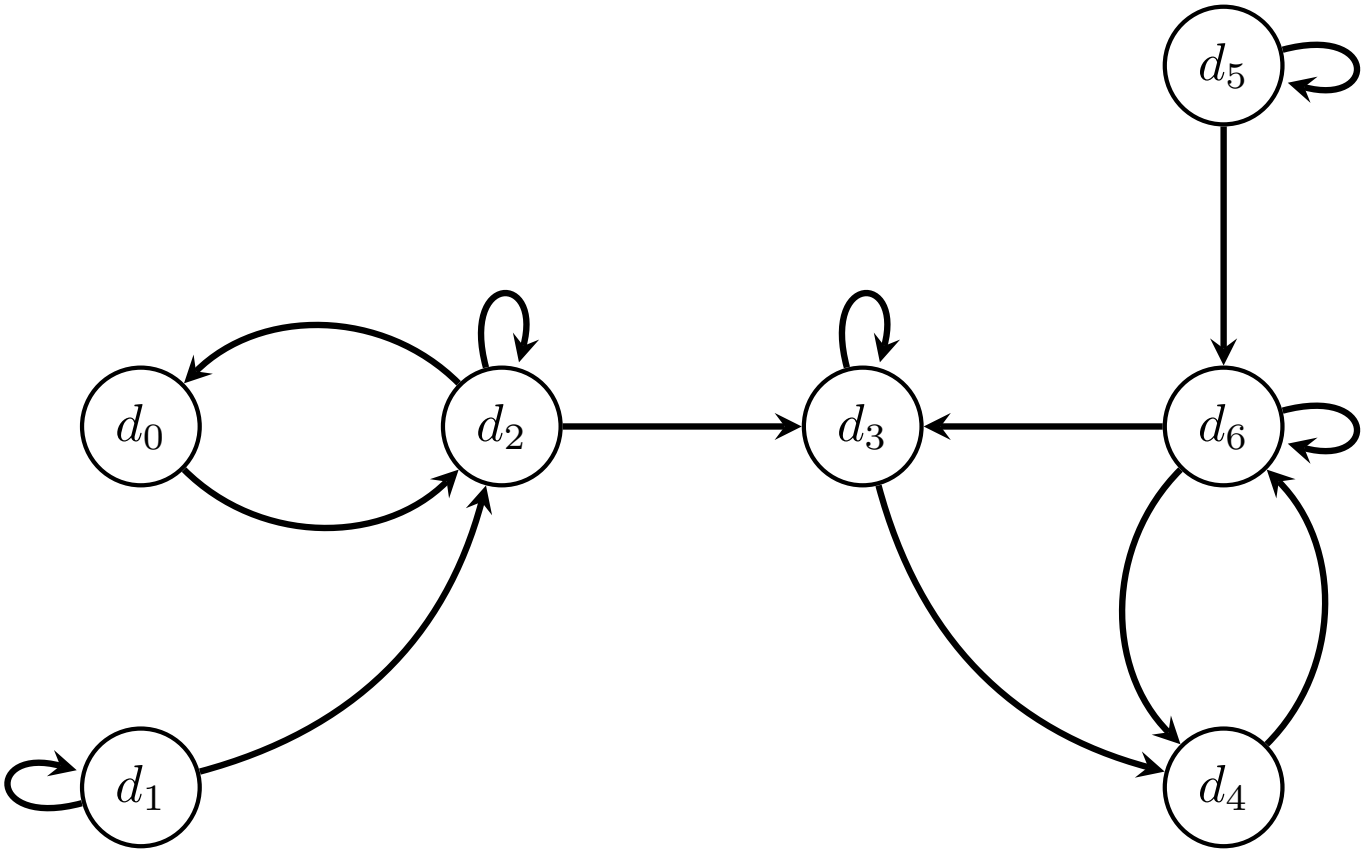



```
\definecolor{olivegreen}{rgb}{0,0.6,0}

\begin{tikzpicture}

        \node (1) [draw, dashed, minimum height=15em, minimum width=15em, xshift=6.5em, fill=olivegreen,
            fill opacity=0.2, very thick, rectangle, rounded corners] {};
        \node (la1) [below=0em of 1] {\emph{encoder}};
        \node (2) [draw, dashed, minimum height=14em, fill = red, fill opacity=0.2,minimum width=14em,
            xshift=19em, very thick, rectangle, rounded corners] {};
        \node (la1) [below=0em of 2] {\emph{decoder}};
        \node (3) [draw, dashed, minimum height=16em, fill = blue, fill opacity=0.2,minimum width=5em,
            xshift=-1.5em, very thick, rectangle, rounded corners] {};
                \node (la3) [below=0em of 3] {\emph{corrupt}};

        \node[circle, thick, fill=red!50, draw] (x1) {};
        \node[circle, thick, draw, fill=red!50, below=1em of x1] (x2) {};
        \node[circle, thick, fill=red!50, draw, below=1em of x2] (x3) {};
        \node[circle, thick, fill=red!50, draw, below=1em of x3] (x4) {};
        \node[circle, thick, fill=red!50, draw, above=1em of x1] (x5) {};
        \node[circle, thick, fill=red!50, draw, above=1em of x5] (x6) {};
        \node[circle, thick, fill=red!50, draw, above=1em of x6] (x7) {};

        \foreach \x in {1,...,7}
                \node at (x\x) (lx\x) {$\sim$};

        \node[circle, thick, fill=white, left=2em of x1, draw] (i1) {};
        \node[circle, thick, draw, fill=white, below=1em of i1] (i2) {};
        \node[circle, thick, fill=white, draw, below=1em of i2] (i3) {};
        \node[circle, thick, fill=white, draw, below=1em of i3] (i4) {};
        \node[circle, thick, fill=white, draw, above=1em of i1] (i5) {};
        \node[circle, thick, fill=white, draw, above=1em of i5] (i6) {};
        \node[circle, thick, fill=white, draw, above=1em of i6] (i7) {};

        \foreach \x in {1,...,7}
                \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
                    post length=1.5mm}, decorate, thick] (i\x) -- (x\x);

        \node[circle, thick, right=4em of x1, fill=white, draw] (xh1) {};
        \node[circle, thick, draw, fill=white, below=1em of xh1] (xh2) {};
        \node[circle, thick, fill=white, draw, below=1em of xh2] (xh3) {};
        \node[circle, thick, fill=white, draw, above=1em of xh1] (xh4) {};
        \node[circle, thick, fill=white, draw, above=1em of xh4] (xh5) {};
        \node[circle, thick, fill=white, draw, right=8em of x1, yshift=5em] (hm1) {};
```

```
\node[circle, thick, draw, fill=white, below=0.5em of hm1] (hm2) {};
\node[circle, thick, draw, fill=white, below=0.5em of hm2] (hm3) {};
\node[circle, thick, draw, fill=white, above=0.5em of hm1] (hm4) {};
\node[circle, thick, fill=white, draw, right=8em of x1, yshift=-3em] (hs1) {};
\node[circle, thick, draw, fill=white, below=0.5em of hs1] (hs2) {};
\node[circle, thick, draw, fill=white, below=0.5em of hs2] (hs3) {};
\node[circle, thick, draw, fill=white, above=0.5em of hs1] (hs4) {};
\node[] at (hm1) (mu1) {$\mu$};
\node[] at (hm2) (mu2) {$\mu$};
\node[] at (hm3) (mu3) {$\mu$};
\node[] at (hm4) (mu4) {$\mu$};
\node[] at (hs1) (s1) {$\sigma$};
\node[] at (hs2) (s2) {$\sigma$};
\node[] at (hs3) (s3) {$\sigma$};
\node[] at (hs4) (s4) {$\sigma$};

\node[circle, thick, fill=lightgray, draw, right=12em of x1, yshift=1em] (h1) {};
\node[circle, thick, draw, fill=lightgray, below=1em of h1] (h2) {};
\node[circle, thick, draw, fill=lightgray, below=1em of h2] (h3) {};
\node[circle, thick, draw, fill=lightgray, above=1em of h1] (h4) {};
\node[circle, thick, right=16em of x1, fill=white, draw] (oh1) {};
\node[circle, thick, draw, fill=white, below=1em of oh1] (oh2) {};
\node[circle, thick, fill=white, draw, below=1em of oh2] (oh3) {};
\node[circle, thick, fill=white, draw, above=1em of oh1] (oh4) {};
\node[circle, thick, fill=white, draw, above=1em of oh4] (oh5) {};
\node[circle, thick, draw, fill=white, right=20em of x1] (o1) {};
\node[circle, thick, draw, fill=white, below=1em of o1] (o2) {};
\node[circle, thick, draw, fill=white, below=1em of o2] (o3) {};
\node[circle, thick, draw, fill=white, below=1em of o3] (o4) {};
\node[circle, thick, draw, fill=white, above=1em of o1] (o5) {};
\node[circle, thick, draw, fill=white, above=1em of o5] (o6) {};
\node[circle, thick, draw, fill=white, above=1em of o6] (o7) {};
\node[circle, thick, draw, fill=white, right=24em of x1] (oo1) {};
\node[circle, thick, draw, fill=white, below=1em of oo1] (oo2) {};
\node[circle, thick, draw, fill=white, below=1em of oo2] (oo3) {};
\node[circle, thick, draw, fill=white, below=1em of oo3] (oo4) {};
\node[circle, thick, draw, fill=white, above=1em of oo1] (oo5) {};
\node[circle, thick, draw, fill=white, above=1em of oo5] (oo6) {};
\node[circle, thick, draw, fill=white, above=1em of oo6] (oo7) {};
\node[] at (o1) (muu1) {$\mu$};
\node[] at (o2) (muu2) {$\mu$};
\node[] at (o3) (muu3) {$\mu$};
\node[] at (o4) (muu4) {$\mu$};
\node[] at (o5) (muu5) {$\mu$};
\node[] at (o6) (muu6) {$\mu$};
\node[] at (o7) (muu7) {$\mu$};

\foreach \x in {1,...,7}
        \foreach \y in {1,...,5}
                \draw[-stealth, thick] (x\x) -- (xh\y);

\foreach \x in {1,...,5}
        \foreach \y in {1,...,4}
                \draw[-stealth, thick] (xh\x) -- (hm\y);

\foreach \x in {1,...,5}
        \foreach \y in {1,...,4}
                \draw[-stealth, thick] (xh\x) -- (hs\y);

\foreach \x in {1,...,4}
        \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate, thick] (hs\x) -- (h\x);
\foreach \x in {1,...,4}
        \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
            post length=1.5mm}, decorate, thick] (hm\x) -- (h\x);

\foreach \x in {1,...,5}
        \foreach \y in {1,...,4}
                \draw[-stealth, thick] (h\y) -- (oh\x);

\foreach \x in {1,...,5}
        \foreach \y in {1,...,7}
                \draw[-stealth, thick] (oh\x) -- (o\y);

\foreach \x in {1,...,7}
        \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm,
```

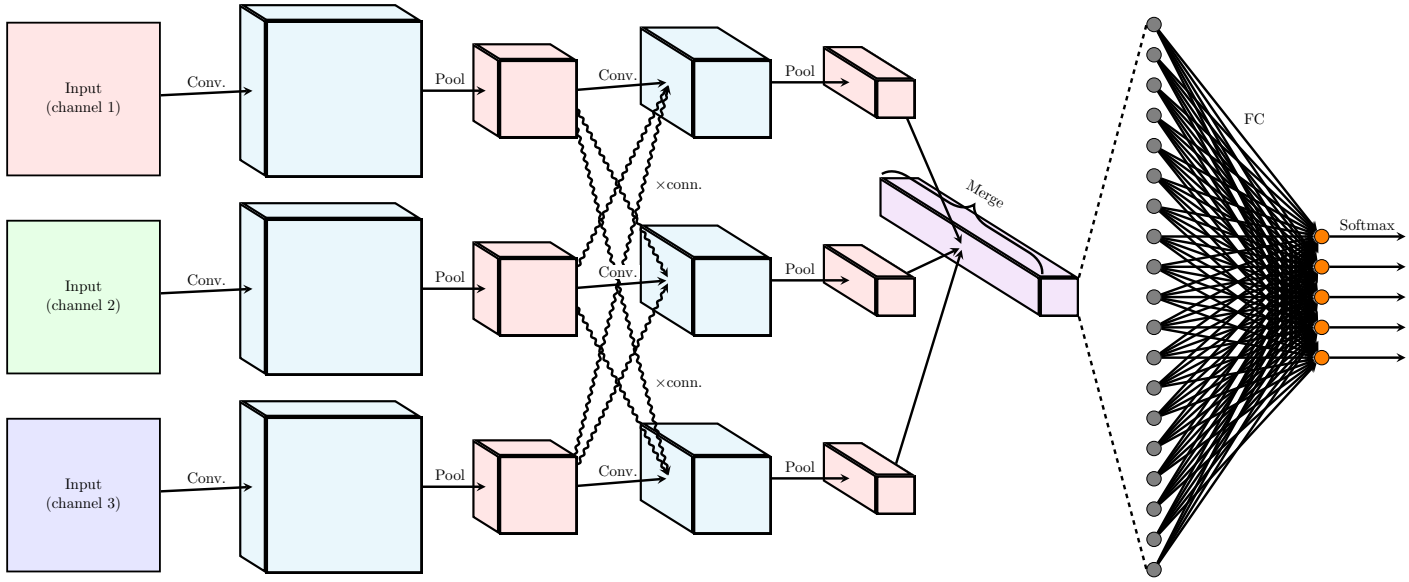
```
                    post length=1.5mm}, decorate, thick] (o\x) -- (oo\x);

        \node[left=0.5em of i1] (l1) {$\vec{x}$};
        \node[above=0em of h4] (l2) {$\vec{z}$};
        \node[right=0.5em of oo1] (l3) {$\vec{x}'$};

\end{tikzpicture}
```

1.62 Web Graph




```
\begin{tikzpicture}
        \node[circle, thick, draw] (0) {$d_0$};
        \node[circle, thick, draw, below = 4.5em of 0] (1) {$d_1$};
        \node[circle, thick, draw, right = 4.5em of 0] (2) {$d_2$};
        \node[circle, thick, draw, right = 4.5em of 2] (3) {$d_3$};
        \node[circle, thick, draw, right = 4.5em of 3] (6) {$d_6$};
        \node[circle, thick, draw, above = 4.5em of 6] (5) {$d_5$};
        \node[circle, thick, draw, below = 4.5em of 6] (4) {$d_4$};

        \path[-stealth, very thick] (0) edge [bend right=45] (2);
        \path[-stealth, very thick] (2) edge [bend right=45] (0);
        \path[-stealth, very thick] (1) edge [bend right] (2);
        \path[-stealth, very thick] (1) edge [->, >=stealth, loop left] (1);
        \path[-stealth, very thick] (2) edge [->, >=stealth, loop above] (2);
        \path[-stealth, very thick] (3) edge [->, >=stealth, loop above] (3);
        \draw[-stealth, very thick] (2) -- (3);
        \path[-stealth, very thick] (3) edge [bend right] (4);
        \draw[-stealth, very thick] (5) -- (6);
        \draw[-stealth, very thick] (6) -- (3);
        \path[-stealth, very thick] (6) edge [bend right=45] (4);
        \path[-stealth, very thick] (4) edge [bend right=45] (6);
        \path[-stealth, very thick] (5) edge [->, >=stealth, loop right] (5);
        \path[-stealth, very thick] (6) edge [->, >=stealth, loop right] (6);
\end{tikzpicture}
```

1.63 X-CNN




```
\definecolor{echoreg}{HTML}{2cb1e1}
\definecolor{mymauve}{rgb}{0.58,0,0.82}

\newtoggle{redraw}
\newtoggle{redraw2}

\tikzset{%
pics/cube/.style args={#1/#2/#3/#4}{code={%
        \begin{scope}[line width=#4mm]
        \begin{scope}
        \clip (-#1,-#2,0) -- (#1,-#2,0) -- (#1,#2,0) -- (-#1,#2,0) -- cycle;
        \filldraw (-#1,-#2,0) -- (#1,-#2,0) -- (#1,#2,0) -- (-#1,#2,0) -- cycle;
        \end{scope}
\iftoggle{redraw}{%
}{%
        \begin{scope}
        \clip (-#1,-#2,0) -- (-#1-#3,-#2,-#3) -- (-#1-#3,#2,-#3) -- (-#1,#2,0) -- cycle;
        \filldraw (-#1,-#2,0) -- (-#1-#3,-#2,-#3) -- (-#1-#3,#2,-#3) -- (-#1,#2,0) -- cycle;
        \end{scope}
}
\iftoggle{redraw2}{%
}{
        \begin{scope}
        \clip (-#1,#2,0) -- (-#1-#3,#2,-#3) -- (#1-#3,#2,-#3) -- (#1,#2,0) -- cycle;
        \filldraw (-#1,#2,0) -- (-#1-#3,#2,-#3) -- (#1-#3,#2,-#3) -- (#1,#2,0) -- cycle;
        \end{scope}
}
        \node[inner sep=0] (-A) at (-#1-#3*0.5, 0, -#3*0.5) {};
        \node[inner sep=0] (-B) at (#1-#3*0.5, 0, -#3*0.5) {};

        \coordinate (-V) at (#1, #2);
        \coordinate (-W) at (#1, -#2);
        \end{scope}
}}}

\begin{tikzpicture}
        \node[rectangle, align=center, draw, very thick, minimum height=10em, minimum width=10em, fill=red
            !10] (i1) {Input\\ (channel 1)};
        \node[rectangle, align=center, draw, very thick, minimum height=10em, minimum width=10em, fill=
            green!10, below=of i1] (i2) {Input\\ (channel 2)};
        \node[rectangle, draw, align=center, very thick, minimum height=10em, minimum width=10em, below=of
            i2, fill=blue!10] (i3) {Input\\ (channel 3)};

        \togglefalse{redraw}
        \togglefalse{redraw2}

        \node[right=12em of i1] (x) {};
        \node[right=12em of i2] (y) {};
        \node[right=12em of i3] (z) {};
        \pic[right=12em of i1, fill=echoreg!10] (X) {cube={1.8/1.8/1/1}};
```

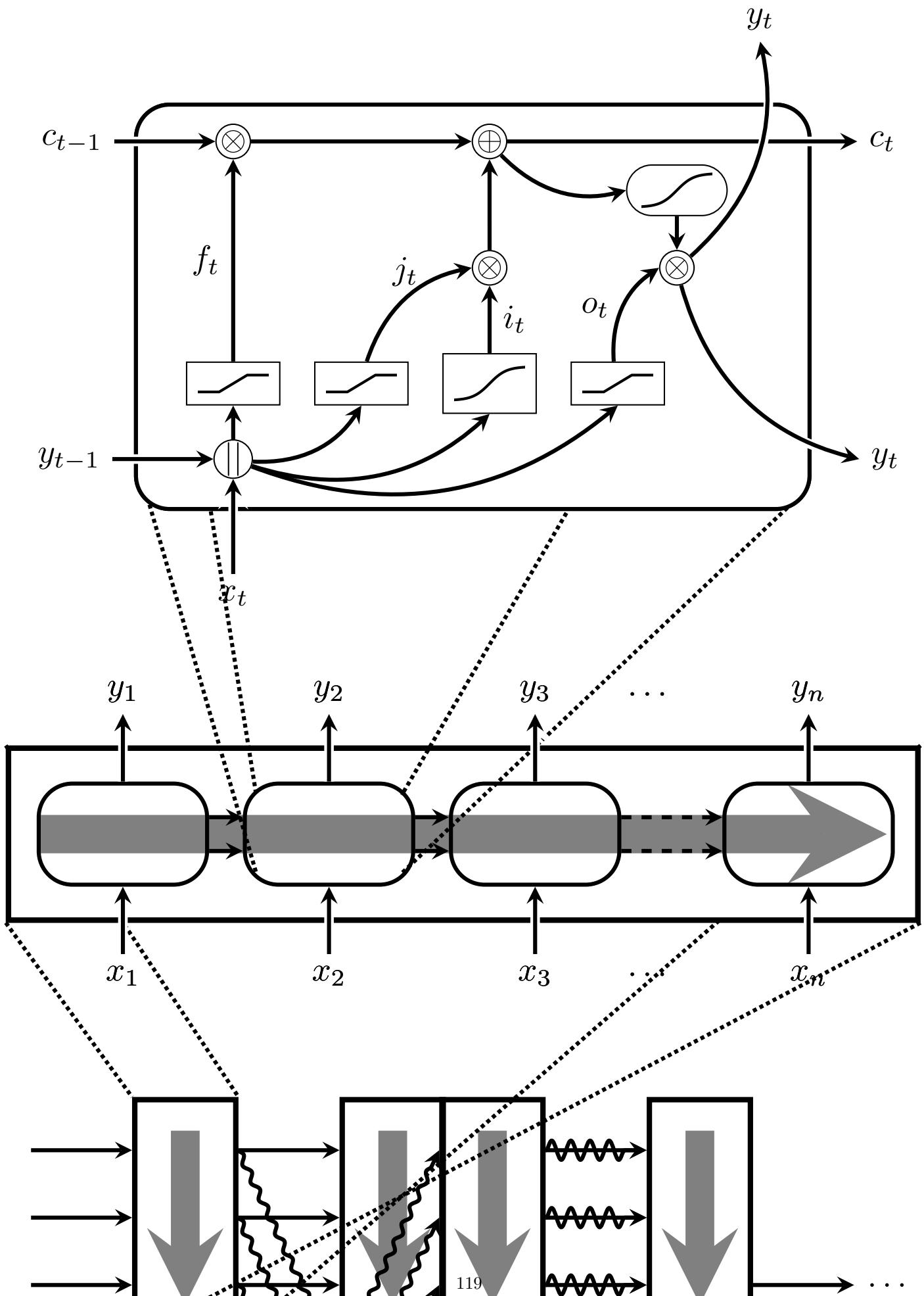
```
\pic[right=12em of i2, fill=echoreg!10] (Y) {cube={1.8/1.8/1/1}};
\pic[right=12em of i3, fill=echoreg!10] (Z) {cube={1.8/1.8/1/1}};


\node[right=12em of x] (x1) {};
\node[right=12em of y] (y1) {};
\node[right=12em of z] (z1) {};
\pic[right=12em of x, fill=red!10] (X1) {cube={0.9/0.9/1/1}};
\pic[right=12em of y, fill=red!10] (Y1) {cube={0.9/0.9/1/1}};
\pic[right=12em of z, fill=red!10] (Z1) {cube={0.9/0.9/1/1}};

\node[right=12em of x1] (x2) {};
\node[right=12em of y1] (y2) {};
\node[right=12em of z1] (z2) {};
\pic[right=12em of x1, fill=echoreg!10] (X2) {cube={0.9/0.9/2/1}};
\pic[right=12em of y1, fill=echoreg!10] (Y2) {cube={0.9/0.9/2/1}};
\pic[right=12em of z1, fill=echoreg!10] (Z2) {cube={0.9/0.9/2/1}};

\node[right=10em of x2] (x3) {};
\node[right=10em of y2] (y3) {};
\node[right=10em of z2] (z3) {};
\pic[right=10em of x2, fill=red!10] (X3) {cube={0.45/0.45/2/1}};
\pic[right=10em of y2, fill=red!10] (Y3) {cube={0.45/0.45/2/1}};
\pic[right=10em of z2, fill=red!10] (Z3) {cube={0.45/0.45/2/1}};

\node[right=10em of y3] (y4) {};
\pic[right=10em of y3, fill=mymauve!10] (Y4) {cube={0.45/0.45/6/1}};

\draw [-stealth, ultra thick] (i1) -- node[above] {Conv.} (X-A);
\draw [-stealth, ultra thick] (i2) -- node[above] {Conv.} (Y-A);
\draw [-stealth, ultra thick] (i3) -- node[above] {Conv.} (Z-A);

\draw [-stealth, ultra thick] (X-B) -- node[above] {Pool} (X1-A);
\draw [-stealth, ultra thick] (Y-B) -- node[above] {Pool} (Y1-A);
\draw [-stealth, ultra thick] (Z-B) -- node[above] {Pool} (Z1-A);

\draw [-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,ultra thick] (X1-B) -- node[right=2em] {$\times$conn.} (Y2-A);
\draw [-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,ultra thick] (X1-B) -- node[above] {} (Z2-A);

\draw [-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,ultra thick] (Y1-B) -- node[above] {} (X2-A);
\draw [-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,ultra thick] (Y1-B) -- node[above] {} (Z2-A);

\draw [-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,ultra thick] (Z1-B) -- node[above] {} (X2-A);
\draw [-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,ultra thick] (Z1-B) -- node[right=2em] {$\times$conn.} (Y2-A);

        \draw [-stealth, ultra thick] (X1-B) -- node[above] {Conv.} (X2-A);
\draw [-stealth, ultra thick] (Y1-B) -- node[above=0.3em, fill=white, inner sep=0.1em] {Conv.} (Y2-
    A);
\draw [-stealth, ultra thick] (Z1-B) -- node[above] {Conv.} (Z2-A);


\draw [-stealth, ultra thick] (X2-B) -- node[above] {Pool} (X3-A);
\draw [-stealth, ultra thick] (Y2-B) -- node[above] {Pool} (Y3-A);
\draw [-stealth, ultra thick] (Z2-B) -- node[above] {Pool} (Z3-A);

        \draw [-stealth, ultra thick] (X3-B) -- (Y4-A);
\draw [-stealth, ultra thick] (Y3-B) -- (Y4-A);
\draw [-stealth, ultra thick] (Z3-B) -- (Y4-A);

\draw [decorate,decoration={brace,amplitude=15pt}, ultra thick, rotate around={238:(20.85,-3.275)}]
     (20.85,-6.2) -- node[above right=1.5em, xshift=-1.5em, yshift=1em, rotate=-30] {Merge}
    (20.85,-1.85);

\node[circle, draw=black, fill=gray, right=5em of y4] (neur0) {};
\node[circle, draw=black, fill=gray, above=1em of neur0] (neur1) {};
\node[circle, draw=black, fill=gray, above=1em of neur1] (neur2) {};
\node[circle, draw=black, fill=gray, above=1em of neur2] (neur3) {};
\node[circle, draw=black, fill=gray, above=1em of neur3] (neur4) {};
\node[circle, draw=black, fill=gray, above=1em of neur4] (neur5) {};
\node[circle, draw=black, fill=gray, above=1em of neur5] (neur6) {};
```

```
\node[circle, draw=black, fill=gray, above=1em of neur6] (neur7) {};
\node[circle, draw=black, fill=gray, above=1em of neur7] (neur8) {};
\node[circle, draw=black, fill=gray, above=1em of neur8] (neur9) {};
\node[circle, draw=black, fill=gray, below=1em of neur0] (neur01) {};
\node[circle, draw=black, fill=gray, below=1em of neur01] (neur02) {};
\node[circle, draw=black, fill=gray, below=1em of neur02] (neur03) {};
\node[circle, draw=black, fill=gray, below=1em of neur03] (neur04) {};
\node[circle, draw=black, fill=gray, below=1em of neur04] (neur05) {};
\node[circle, draw=black, fill=gray, below=1em of neur05] (neur06) {};
\node[circle, draw=black, fill=gray, below=1em of neur06] (neur07) {};
\node[circle, draw=black, fill=gray, below=1em of neur07] (neur08) {};
\node[circle, draw=black, fill=gray, below=1em of neur08] (neur09) {};

\draw [dashed, ultra thick] (Y4-V) -- (neur9.west);
\draw [dashed, ultra thick] (Y4-W) -- (neur09.west);

\node[circle, draw=black, fill=orange, right=10em of neur0] (neur00) {};
\node[circle, draw=black, fill=orange, above=1em of neur00] (neur11) {};
\node[circle, draw=black, fill=orange, above=1em of neur11] (neur12) {};
\node[circle, draw=black, fill=orange, below=1em of neur00] (neur001) {};
\node[circle, draw=black, fill=orange, below=1em of neur001] (neur002) {};

\draw [-stealth, ultra thick] (neur9) -- node[above right] {FC} (neur12);


\draw [-stealth, ultra thick] (neur9) -- (neur11);
\draw [-stealth, ultra thick] (neur9) -- (neur00);
\draw [-stealth, ultra thick] (neur9) -- (neur001);
\draw [-stealth, ultra thick] (neur9) -- (neur002);

       \draw [-stealth, ultra thick] (neur09) -- (neur11);
\draw [-stealth, ultra thick] (neur09) -- (neur00);
\draw [-stealth, ultra thick] (neur09) -- (neur001);
\draw [-stealth, ultra thick] (neur09) -- (neur12);



\draw [-stealth, ultra thick] (neur8) -- (neur12);
\draw [-stealth, ultra thick] (neur8) -- (neur11);
\draw [-stealth, ultra thick] (neur8) -- (neur00);
\draw [-stealth, ultra thick] (neur8) -- (neur001);
\draw [-stealth, ultra thick] (neur8) -- (neur002);

\draw [-stealth, ultra thick] (neur7) -- (neur12);
\draw [-stealth, ultra thick] (neur7) -- (neur11);
\draw [-stealth, ultra thick] (neur7) -- (neur00);
\draw [-stealth, ultra thick] (neur7) -- (neur001);
\draw [-stealth, ultra thick] (neur7) -- (neur002);

\draw [-stealth, ultra thick] (neur6) -- (neur12);
\draw [-stealth, ultra thick] (neur6) -- (neur11);
\draw [-stealth, ultra thick] (neur6) -- (neur00);
\draw [-stealth, ultra thick] (neur6) -- (neur001);
\draw [-stealth, ultra thick] (neur6) -- (neur002);

\draw [-stealth, ultra thick] (neur5) -- (neur12);
\draw [-stealth, ultra thick] (neur5) -- (neur11);
\draw [-stealth, ultra thick] (neur5) -- (neur00);
\draw [-stealth, ultra thick] (neur5) -- (neur001);
\draw [-stealth, ultra thick] (neur5) -- (neur002);

\draw [-stealth, ultra thick] (neur4) -- (neur12);
\draw [-stealth, ultra thick] (neur4) -- (neur11);
\draw [-stealth, ultra thick] (neur4) -- (neur00);
\draw [-stealth, ultra thick] (neur4) -- (neur001);
\draw [-stealth, ultra thick] (neur4) -- (neur002);

\draw [-stealth, ultra thick] (neur3) -- (neur12);
\draw [-stealth, ultra thick] (neur3) -- (neur11);
\draw [-stealth, ultra thick] (neur3) -- (neur00);
\draw [-stealth, ultra thick] (neur3) -- (neur001);
\draw [-stealth, ultra thick] (neur3) -- (neur002);

\draw [-stealth, ultra thick] (neur2) -- (neur12);
\draw [-stealth, ultra thick] (neur2) -- (neur11);
\draw [-stealth, ultra thick] (neur2) -- (neur00);
```

```
        \draw [-stealth, ultra thick] (neur2) -- (neur001);
        \draw [-stealth, ultra thick] (neur2) -- (neur002);

        \draw [-stealth, ultra thick] (neur1) -- (neur12);
        \draw [-stealth, ultra thick] (neur1) -- (neur11);
        \draw [-stealth, ultra thick] (neur1) -- (neur00);
        \draw [-stealth, ultra thick] (neur1) -- (neur001);
        \draw [-stealth, ultra thick] (neur1) -- (neur002);

        \draw [-stealth, ultra thick] (neur0) -- (neur12);
        \draw [-stealth, ultra thick] (neur0) -- (neur11);
        \draw [-stealth, ultra thick] (neur0) -- (neur00);
        \draw [-stealth, ultra thick] (neur0) -- (neur001);
        \draw [-stealth, ultra thick] (neur0) -- (neur002);

          \draw [-stealth, ultra thick] (neur08) -- (neur12);
        \draw [-stealth, ultra thick] (neur08) -- (neur11);
        \draw [-stealth, ultra thick] (neur08) -- (neur00);
        \draw [-stealth, ultra thick] (neur08) -- (neur001);
        \draw [-stealth, ultra thick] (neur08) -- (neur002);

        \draw [-stealth, ultra thick] (neur07) -- (neur12);
        \draw [-stealth, ultra thick] (neur07) -- (neur11);
        \draw [-stealth, ultra thick] (neur07) -- (neur00);
        \draw [-stealth, ultra thick] (neur07) -- (neur001);
        \draw [-stealth, ultra thick] (neur07) -- (neur002);

        \draw [-stealth, ultra thick] (neur06) -- (neur12);
        \draw [-stealth, ultra thick] (neur06) -- (neur11);
        \draw [-stealth, ultra thick] (neur06) -- (neur00);
        \draw [-stealth, ultra thick] (neur06) -- (neur001);
        \draw [-stealth, ultra thick] (neur06) -- (neur002);

        \draw [-stealth, ultra thick] (neur05) -- (neur12);
        \draw [-stealth, ultra thick] (neur05) -- (neur11);
        \draw [-stealth, ultra thick] (neur05) -- (neur00);
        \draw [-stealth, ultra thick] (neur05) -- (neur001);
        \draw [-stealth, ultra thick] (neur05) -- (neur002);

        \draw [-stealth, ultra thick] (neur04) -- (neur12);
        \draw [-stealth, ultra thick] (neur04) -- (neur11);
        \draw [-stealth, ultra thick] (neur04) -- (neur00);
        \draw [-stealth, ultra thick] (neur04) -- (neur001);
        \draw [-stealth, ultra thick] (neur04) -- (neur002);

        \draw [-stealth, ultra thick] (neur03) -- (neur12);
        \draw [-stealth, ultra thick] (neur03) -- (neur11);
        \draw [-stealth, ultra thick] (neur03) -- (neur00);
        \draw [-stealth, ultra thick] (neur03) -- (neur001);
        \draw [-stealth, ultra thick] (neur03) -- (neur002);

        \draw [-stealth, ultra thick] (neur02) -- (neur12);
        \draw [-stealth, ultra thick] (neur02) -- (neur11);
        \draw [-stealth, ultra thick] (neur02) -- (neur00);
        \draw [-stealth, ultra thick] (neur02) -- (neur001);
        \draw [-stealth, ultra thick] (neur02) -- (neur002);

        \draw [-stealth, ultra thick] (neur01) -- (neur12);
        \draw [-stealth, ultra thick] (neur01) -- (neur11);
        \draw [-stealth, ultra thick] (neur01) -- (neur00);
        \draw [-stealth, ultra thick] (neur01) -- (neur001);
        \draw [-stealth, ultra thick] (neur01) -- (neur002);

        \node[right=5em of neur12] (out1) {};
        \node[right=5em of neur11] (out2) {};
        \node[right=5em of neur00] (out3) {};
        \node[right=5em of neur001] (out4) {};
        \node[right=5em of neur002] (out5) {};

        \draw[-stealth, ultra thick] (neur12) -- node[above] {Softmax} (out1);
        \draw[-stealth, ultra thick] (neur11) -- (out2);
        \draw[-stealth, ultra thick] (neur00) -- (out3);
        \draw[-stealth, ultra thick] (neur001) -- (out4);
        \draw[-stealth, ultra thick] (neur002) -- (out5);

        \toggletrue{redraw}
```

```
        \toggletrue{redraw2}

        \node[right=12em of i1] (x) {};
        \node[right=12em of i2] (y) {};
        \node[right=12em of i3] (z) {};
        \pic[right=12em of i1, fill=echoreg!10] (X) {cube={1.8/1.8/1/1}};
        \pic[right=12em of i2, fill=echoreg!10] (Y) {cube={1.8/1.8/1/1}};
        \pic[right=12em of i3, fill=echoreg!10] (Z) {cube={1.8/1.8/1/1}};


        \pic[right=12em of x, fill=red!10] (X1) {cube={0.9/0.9/1/1}};
        \pic[right=12em of y, fill=red!10] (Y1) {cube={0.9/0.9/1/1}};
        \pic[right=12em of z, fill=red!10] (Z1) {cube={0.9/0.9/1/1}};

        \pic[right=12em of x1, fill=echoreg!10] (X2) {cube={0.9/0.9/2/1}};
        \pic[right=12em of y1, fill=echoreg!10] (Y2) {cube={0.9/0.9/2/1}};
        \pic[right=12em of z1, fill=echoreg!10] (Z2) {cube={0.9/0.9/2/1}};

        \togglefalse{redraw2}

        \pic[right=10em of x2, fill=red!10] (X3) {cube={0.45/0.45/2/1}};
        \pic[right=10em of y2, fill=red!10] (Y3) {cube={0.45/0.45/2/1}};
        \pic[right=10em of z2, fill=red!10] (Z3) {cube={0.45/0.45/2/1}};

        \toggletrue{redraw2}

        \pic[right=10em of y3, fill=mymauve!10] (Y4) {cube={0.45/0.45/6/1}};

\end{tikzpicture}
```

1.64 X-LSTM


y_t
c_{t-1}
c_t
f_t
j_t
i_t
o_t
y_{t-1}
y_t
x_t
y_1
y_2
y_3
$\cdots$
y_n
x_1
x_2
x_3
$\cdots$
x_n
$\cdots$

```
\begin{tikzpicture}
        \node[rectangle, rounded corners=10, minimum width=20em, minimum height=12em, draw, very thick] (
            lstm) at (0, 0) {};


        \node[rectangle, rounded corners=10, minimum width=5em, minimum height=3em, draw, very thick] (lst
            2) at (-1.5, -5.5) {};

        \node[rectangle, rounded corners=10, minimum width=5em, minimum height=3em, draw, very thick,left=1
            em of lst2] (lst1) {};

        \node[rectangle, rounded corners=10, minimum width=5em, minimum height=3em, draw, very thick,right
            =1em of lst2] (lst3) {};

        \node[right=0.5em of lst3] (dots) {};

        \node[rectangle, rounded corners=10, minimum width=5em, minimum height=3em, draw, very thick,right
            =3em of lst3] (lst4) {};

        \node[rectangle, minimum width=27em, minimum height=5.1em, ultra thick, draw] at (-0.1, -5.5) (chn
            1) {};
        \begin{scope}[transparency group, opacity=0.5]
        \draw[-stealth, line width=4mm] ([xshift=+1em]chn1.west) -- ([xshift=-1em]chn1.east);
        \end{scope}

        \node[below=2em of lst1] (x1) {$x_1$};
        \node[below=2em of lst2] (x2) {$x_2$};
        \node[below=2em of lst3] (x3) {$x_3$};
        \node[below=3.4em of dots] (xd) {\dots};
        \node[below=2em of lst4] (x4) {$x_n$};
        \node[above=2em of lst1] (y1) {$y_1$};
        \node[above=2em of lst2] (y2) {$y_2$};
        \node[above=2em of lst3] (y3) {$y_3$};
        \node[above=3.4em of dots] (yd) {\dots};
        \node[above=2em of lst4] (y4) {$y_n$};

        \draw[-stealth, line width=1mm, white] (x1) -- (lst1);
        \draw[-stealth, line width=1mm, white] (x2) -- (lst2);
        \draw[-stealth, line width=1mm, white] (x3) -- (lst3);
        \draw[-stealth, line width=1mm, white] (x4) -- (lst4);
        \draw[-stealth, very thick] (x1) -- (lst1);
        \draw[-stealth, very thick] (x2) -- (lst2);
        \draw[-stealth, very thick] (x3) -- (lst3);
        \draw[-stealth, very thick] (x4) -- (lst4);

        \draw[-stealth, line width=1mm, white] (lst1) -- (y1);
        \draw[-stealth, line width=1mm, white] (lst2) -- (y2);
        \draw[-stealth, line width=1mm, white] (lst3) -- (y3);
        \draw[-stealth, line width=1mm, white] (lst4) -- (y4);
        \draw[-stealth, very thick] (lst1) -- (y1);
        \draw[-stealth, very thick] (lst2) -- (y2);
        \draw[-stealth, very thick] (lst3) -- (y3);
        \draw[-stealth, very thick] (lst4) -- (y4);

        \draw[-stealth, very thick] ([yshift=-0.5em]lst1.east) -- ([yshift=-0.5em]lst2.west);
        \draw[-stealth, very thick] ([yshift=+0.5em]lst1.east) -- ([yshift=+0.5em]lst2.west);
        \draw[-stealth, very thick] ([yshift=-0.5em]lst2.east) -- ([yshift=-0.5em]lst3.west);
        \draw[-stealth, very thick] ([yshift=+0.5em]lst2.east) -- ([yshift=+0.5em]lst3.west);
        \draw[-stealth, dashed, very thick] ([yshift=-0.5em]lst3.east) -- ([yshift=-0.5em]lst4.west);
        \draw[-stealth, dashed, very thick] ([yshift=+0.5em]lst3.east) -- ([yshift=+0.5em]lst4.west);

        \node[rectangle, minimum width=3em, minimum height=7em, ultra thick, draw] at (-3, -9.5) (chn2) {};
        \draw[-stealth, line width=3mm, black!50] ([yshift=-1em]chn2.north) -- ([yshift=+1em]chn2.south);

        \node[rectangle, minimum width=3em, minimum height=7em, ultra thick, below=5.5em of chn2, draw] (
            chn22) {};
        \draw[-stealth, line width=3mm, black!50] ([yshift=-1em]chn22.north) -- ([yshift=+1em]chn22.south);

        \node[rectangle, minimum width=3em, minimum height=7em, ultra thick, right=3em of chn2, draw] (chn
            3) {};
        \draw[-stealth, line width=3mm, black!50] ([yshift=-1em]chn3.north) -- ([yshift=+1em]chn3.south);
        \node[rectangle, minimum width=3em, minimum height=7em, ultra thick, right=-0.2em of chn3, draw] (
            chn31) {};
        \draw[-stealth, line width=3mm, black!50] ([yshift=-1em]chn31.north) -- ([yshift=+1em]chn31.south);
```

```
\node[rectangle, minimum width=3em, minimum height=7em, ultra thick, right=3em of chn22, draw] (chn
    23) {};
\draw[-stealth, line width=3mm, black!50] ([yshift=-1em]chn23.north) -- ([yshift=+1em]chn23.south);
\node[rectangle, minimum width=3em, minimum height=7em, ultra thick, right=-0.2em of chn23, draw] (
    chn231) {};
\draw[-stealth, line width=3mm, black!50] ([yshift=-1em]chn231.north) -- ([yshift=+1em]chn231.south
    );


\node[rectangle, minimum width=3em, minimum height=7em, ultra thick, right=3em of chn31, draw] (chn
    4) {};
\draw[-stealth, line width=3mm, black!50] ([yshift=-1em]chn4.north) -- ([yshift=+1em]chn4.south);



\node[rectangle, minimum width=3em, minimum height=7em, ultra thick, right=3em of chn231, draw] (
    chn24) {};
\draw[-stealth, line width=3mm, black!50] ([yshift=-1em]chn24.north) -- ([yshift=+1em]chn24.south);

\draw[-stealth, very thick] ([xshift=-3em,yshift=-2em]chn2.west) -- ([yshift=-2em]chn2.west);
\draw[-stealth, very thick] ([xshift=-3em,yshift=2em]chn2.west) -- ([yshift=2em]chn2.west);
\draw[-stealth, very thick] ([xshift=-3em]chn2.west) -- (chn2.west);


\draw[-stealth, very thick] ([yshift=-2em]chn2.east) -- ([yshift=-2em]chn3.west);
\draw[-stealth, very thick] ([yshift=2em]chn2.east) -- ([yshift=2em]chn3.west);
\draw[-stealth, very thick] (chn2.east) -- (chn3.west);

\draw[-stealth, very thick] ([yshift=-2em]chn31.east) -- ([yshift=-2em]chn4.west);
\draw[-stealth, very thick] ([yshift=2em]chn31.east) -- ([yshift=2em]chn4.west);
\draw[-stealth, very thick] (chn31.east) -- (chn4.west);


\draw[-stealth, very thick] ([yshift=-2em]chn4.east) -- ([yshift=-2em,xshift=3em]chn4.east) node[
    right] {\dots};

\draw[-stealth, very thick] ([xshift=-3em,yshift=-2em]chn22.west) -- ([yshift=-2em]chn22.west);
\draw[-stealth, very thick] ([xshift=-3em,yshift=2em]chn22.west) -- ([yshift=2em]chn22.west);
\draw[-stealth, very thick] ([xshift=-3em]chn22.west) -- (chn22.west);


\draw[-stealth, very thick] ([yshift=-2em]chn22.east) -- ([yshift=-2em]chn23.west);
\draw[-stealth, very thick] ([yshift=2em]chn22.east) -- ([yshift=2em]chn23.west);
\draw[-stealth, very thick] (chn22.east) -- (chn23.west);

\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,very thick] ([yshift=-2em]chn2.east) -- ([yshift=-2em]chn231.west);
\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,very thick] ([yshift=2em]chn2.east) -- ([yshift=2em]chn231.west);
\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,very thick] (chn2.east) -- (chn231.west);

\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,very thick] ([yshift=-2em]chn22.east) -- ([yshift=-2em]chn31.west);
\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,very thick] ([yshift=2em]chn22.east) -- ([yshift=2em]chn31.west);
\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=0.3mm, post
    length=1.5mm}, decorate,very thick] (chn22.east) -- (chn31.west);

\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=1mm, post
    length=1.5mm}, decorate,very thick] ([yshift=-2em]chn31.east) -- ([yshift=-2em]chn4.west);
\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=1mm, post
    length=1.5mm}, decorate,very thick] ([yshift=2em]chn31.east) -- ([yshift=2em]chn4.west);
\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=1mm, post
    length=1.5mm}, decorate,very thick] (chn31.east) -- (chn4.west);

        \draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=1mm,
            post length=1.5mm}, decorate,very thick] ([yshift=-2em]chn231.east) -- ([yshift=-2em]
            chn24.west);
\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=1mm, post
    length=1.5mm}, decorate,very thick] ([yshift=2em]chn231.east) -- ([yshift=2em]chn24.west);
\draw[-stealth, decoration={snake, pre length=0.01mm, segment length=2mm, amplitude=1mm, post
    length=1.5mm}, decorate,very thick] (chn231.east) -- (chn24.west);

\draw[-stealth, very thick] ([yshift=-2em]chn231.east) -- ([yshift=-2em]chn24.west);
```

```
\draw[-stealth, very thick] ([yshift=2em]chn231.east) -- ([yshift=2em]chn24.west);
\draw[-stealth, very thick] (chn231.east) -- (chn24.west);


\draw[-stealth, very thick] ([yshift=-2em]chn24.east) -- ([yshift=-2em,xshift=3em]chn24.east) node[
    right] {\dots};

\draw[densely dotted, very thick] (chn1.north west) -- (chn2.north east);
\draw[densely dotted, very thick] (chn1.north east) -- (chn2.south east);
\draw[densely dotted, very thick] (chn1.south west) -- (chn2.north west);
\draw[densely dotted, very thick] (chn1.south east) -- (chn2.south west);

\node[rectangle, minimum width=27em, minimum height=5.1em, ultra thick, draw, fill=white] at (-0.1,
     -5.5) (chn1) {};

\draw[densely dotted, very thick] ([xshift=0.4em,yshift=-0.4em]lstm.north west) -- ([xshift=0.4em,
    yshift=-0.4em]lst2.north west);

\draw[densely dotted, very thick] ([xshift=-0.4em,yshift=-0.4em]lstm.north east) -- ([xshift=-0.4em
    ,yshift=-0.4em]lst2.north east);

\draw[densely dotted, very thick] ([xshift=-0.4em,yshift=0.4em]lstm.south east) -- ([xshift=-0.4em,
    yshift=0.4em]lst2.south east);

\draw[densely dotted, very thick] ([xshift=0.4em,yshift=0.4em]lstm.south west) -- ([xshift=0.4em,
    yshift=0.4em]lst2.south west);

\node[rectangle, rounded corners=10, minimum width=20em, minimum height=12em, draw, very thick,
    fill=white] (lstm) at (0, 0) {};

\node[rectangle, draw] at (-2.5, -0.8) (s1) {\begin{tikzpicture} \begin{axis}[
                samples=1000, domain=-2.6:2.6,
                        hide axis,
                        xtick=\empty,
                        ytick=\empty,
                        xlabel=\empty,
                        ylabel=\empty,
                        xmin=-2.1, xmax=2.1,
                        ymin=-0.1, ymax=1.1,
                        x=0.5em, y=0.5em,
                        trig format = rad
                ]
                        \addplot expression [no markers, smooth, thick, black] {max(0, min(1, x*0.6
                             + 0.5))};
                \end{axis}\end{tikzpicture}};
\node[rectangle, draw, right=1em of s1] (s2) {\begin{tikzpicture} \begin{axis}[
                samples=1000, domain=-2.6:2.6,
                        hide axis,
                        xtick=\empty,
                        ytick=\empty,
                        xlabel=\empty,
                        ylabel=\empty,
                        xmin=-2.1, xmax=2.1,
                        ymin=-0.1, ymax=1.1,
                        x=0.5em, y=0.5em,
                        trig format = rad
                ]
                        \addplot expression [no markers, smooth, thick, black] {max(0, min(1, x*0.6
                             + 0.5))};
                \end{axis}\end{tikzpicture}};
\node[rectangle, draw, right=1em of s2] (t1) {\begin{tikzpicture} \begin{axis}[
                samples=1000, domain=-2.6:2.6,
                        hide axis,
                        xtick=\empty,
                        ytick=\empty,
                        xlabel=\empty,
                        ylabel=\empty,
                        xmin=-2.1, xmax=2.1,
                        ymin=-1.1, ymax=1.1,
                        x=0.5em, y=0.5em,
                        trig format = rad
                ]
                        \addplot expression [no markers, smooth, thick, black] {tanh(\x)};
                \end{axis}\end{tikzpicture}};
\node[rectangle, draw, right=1em of t1] (s3) {\begin{tikzpicture} \begin{axis}[
                samples=1000, domain=-2.6:2.6,
```

```
                        hide axis,
                        xtick=\empty,
                        ytick=\empty,
                        xlabel=\empty,
                        ylabel=\empty,
                        xmin=-2.1, xmax=2.1,
                        ymin=-0.1, ymax=1.1,
                        x=0.5em, y=0.5em,
                        trig format = rad
                ]
                        \addplot expression [no markers, smooth, thick, black] {max(0, min(1, x*0.6
                            + 0.5))};
                \end{axis}\end{tikzpicture}};
\node[circle, draw, above=2em of t1, inner sep=0em] (m1) {$\otimes$};
\node[circle, draw, above=6em of s1, inner sep=0em] (m2) {$\otimes$};
\node[circle, draw, right=6.55em of m2, inner sep=0em] (p1) {$\oplus$};
\node[circle, draw, right=4.5em of m1, inner sep=0em] (m3) {$\otimes$};
\node[rounded rectangle, draw, above=1em of m3, inner sep=0.2em] (tt) {\begin{tikzpicture} \begin{
    axis}[
                samples=1000, domain=-2.6:2.6,
                        hide axis,
                        xtick=\empty,
                        ytick=\empty,
                        xlabel=\empty,
                        ylabel=\empty,
                        xmin=-2.1, xmax=2.1,
                        ymin=-1.1, ymax=1.1,
                        x=0.5em, y=0.5em,
                        trig format = rad
                ]
                        \addplot expression [no markers, smooth, thick, black] {tanh(\x)};
                \end{axis}\end{tikzpicture}};

\node[circle, draw, below=1em of s1, inner sep=0em] (conc) {$||$};

\node[below=5em of s1] (xt) {$x_t$};
\node[left=3em of conc] (ht1) {$y_{t-1}$};
\node[left=3em of m2] (ct1) {$c_{t-1}$};
\node[right=18em of m2] (ct) {$c_t$};
\node[right=18em of conc] (ht) {$y_t$};
\node[] (yt) at (3, 3) {$y_t$};

\draw[-stealth, line width=1mm, white] (xt) -- (conc);
\draw[-stealth, very thick] (xt) -- (conc);
\draw[-stealth, line width=1mm, white] (ht1) -- (conc);
\draw[-stealth, very thick] (ht1) -- (conc);

\draw[-stealth, very thick] (conc) -- (s1);
\path[-stealth, very thick] (conc) edge[bend right] (s2.south);
\path[-stealth, very thick] (conc) edge[bend right] (t1.south);
\path[-stealth, very thick] (conc) edge[bend right] (s3.south);
\draw[-stealth, very thick] (s1) -- node[left] {$f_t$} (m2);
\draw[-stealth, very thick] (s2) edge[bend left] node[above] {$j_t$} (m1.west);
\draw[-stealth, very thick] (t1) -- node[right] {$i_t$} (m1);
\draw[-stealth, very thick] (m1) -- (p1);
\draw[-stealth, line width=1mm, white] (ct1) -- (m2);
\draw[-stealth, very thick] (ct1) -- (m2);
\draw[-stealth, very thick] (m2) -- (p1);
\draw[-stealth, very thick] (s3) edge[bend left] node[left] {$o_t$} (m3.west);

\draw[-stealth, line width=1mm, white] (p1) -- (ct);
\draw[-stealth, very thick] (p1) -- (ct);
\draw[-stealth, very thick] (tt) -- (m3);
\draw[-stealth, line width=1mm, white] (m3) edge[bend right] (ht.west);
\draw[-stealth, very thick] (m3) edge[bend right] (ht.west);

\draw[-stealth ,very thick] (p1) edge[bend right] (tt.west);
\draw[-stealth, line width=1mm,white] (m3) edge[bend right] (yt.south);
\draw[-stealth, very thick] (m3) edge[bend right] (yt.south);

\node[rectangle, rounded corners=10, minimum width=5em, minimum height=3em, draw, very thick] (lst
    2) at (-1.5, -5.5) {};

\node[rectangle, rounded corners=10, minimum width=5em, minimum height=3em, draw, very thick,left=1
    em of lst2] (lst1) {};
```

```
        \node[rectangle, rounded corners=10, minimum width=5em, minimum height=3em, draw, very thick,right
            =1em of lst2] (lst3) {};

        \node[right=0.5em of lst3] (dots) {};

        \node[rectangle, rounded corners=10, minimum width=5em, minimum height=3em, draw, very thick,right
            =3em of lst3] (lst4) {};

        \begin{scope}[transparency group, opacity=0.5]
        \draw[-stealth, line width=4mm] ([xshift=+1em]chn1.west) -- ([xshift=-1em]chn1.east);
        \end{scope}

        \node[below=2em of lst1] (x1) {$x_1$};
        \node[below=2em of lst2] (x2) {$x_2$};
        \node[below=2em of lst3] (x3) {$x_3$};
        \node[below=3.4em of dots] (xd) {\dots};
        \node[below=2em of lst4] (x4) {$x_n$};
        \node[above=2em of lst1] (y1) {$y_1$};
        \node[above=2em of lst2] (y2) {$y_2$};
        \node[above=2em of lst3] (y3) {$y_3$};
        \node[above=3.4em of dots] (yd) {\dots};
        \node[above=2em of lst4] (y4) {$y_n$};

        \draw[-stealth, line width=1mm, white] (x1) -- (lst1);
        \draw[-stealth, line width=1mm, white] (x2) -- (lst2);
        \draw[-stealth, line width=1mm, white] (x3) -- (lst3);
        \draw[-stealth, line width=1mm, white] (x4) -- (lst4);
        \draw[-stealth, very thick] (x1) -- (lst1);
        \draw[-stealth, very thick] (x2) -- (lst2);
        \draw[-stealth, very thick] (x3) -- (lst3);
        \draw[-stealth, very thick] (x4) -- (lst4);

        \draw[-stealth, line width=1mm, white] (lst1) -- (y1);
        \draw[-stealth, line width=1mm, white] (lst2) -- (y2);
        \draw[-stealth, line width=1mm, white] (lst3) -- (y3);
        \draw[-stealth, line width=1mm, white] (lst4) -- (y4);
        \draw[-stealth, very thick] (lst1) -- (y1);
        \draw[-stealth, very thick] (lst2) -- (y2);
        \draw[-stealth, very thick] (lst3) -- (y3);
        \draw[-stealth, very thick] (lst4) -- (y4);

        \draw[-stealth, very thick] ([yshift=-0.5em]lst1.east) -- ([yshift=-0.5em]lst2.west);
        \draw[-stealth, very thick] ([yshift=+0.5em]lst1.east) -- ([yshift=+0.5em]lst2.west);
        \draw[-stealth, very thick] ([yshift=-0.5em]lst2.east) -- ([yshift=-0.5em]lst3.west);
        \draw[-stealth, very thick] ([yshift=+0.5em]lst2.east) -- ([yshift=+0.5em]lst3.west);
        \draw[-stealth, dashed, very thick] ([yshift=-0.5em]lst3.east) -- ([yshift=-0.5em]lst4.west);
        \draw[-stealth, dashed, very thick] ([yshift=+0.5em]lst3.east) -- ([yshift=+0.5em]lst4.west);

\end{tikzpicture}
```