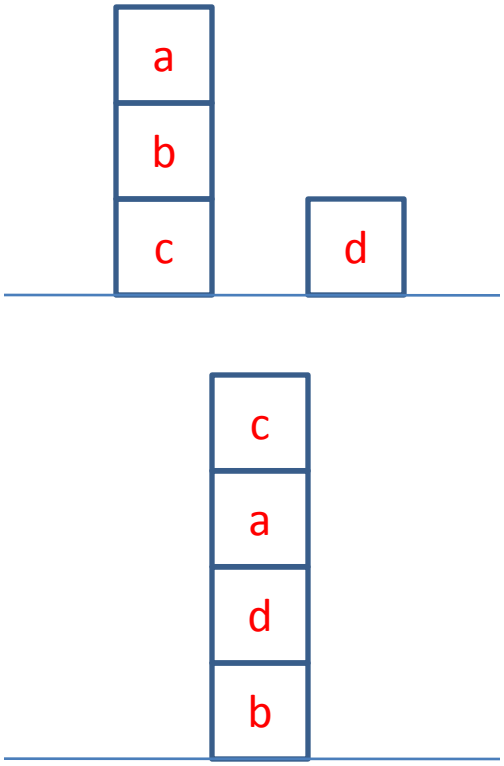
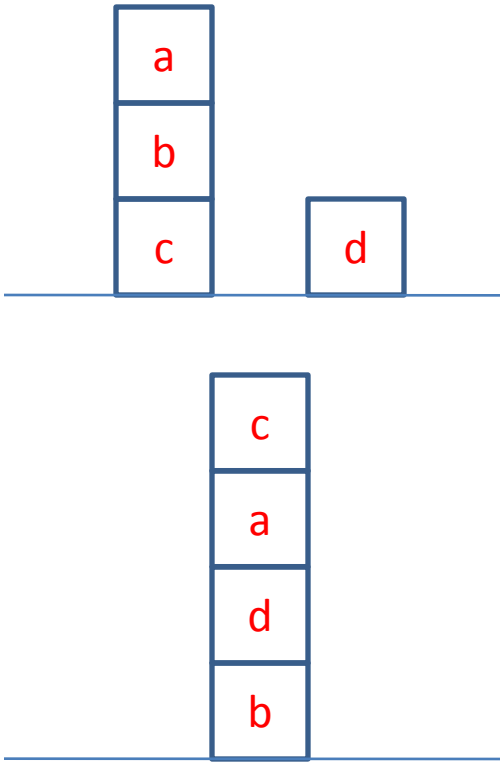
Planning Problem



- stack(x,y)
  - Pre: holding(x), clear(y)
  - Add: on(x,y), clear(x), empty
  - Del: clear(y), holding(x)
- unstack(x,y)
  - Pre: empty, clear(x), on(x,y)
  - Add: clear(y), holding(x)
  - Del: on(x,y), clear(x), empty
- putdown(x)
  - Pre: holding(x)
  - Add: on(x,T), clear(x), empty
  - Del: holding(x)
- pickup(x)
  - Pre: empty, clear(x), on(x,T)
  - Add: holding(x)
  - Del: on(x,T), clear(x), empty

Relaxed Planning Problem



- stack(x,y)
  - Pre: holding(x), clear(y)
  - Add: on(x,y), clear(x), empty
  - Del:
- unstack(x,y)
  - Pre: empty, clear(x), on(x,y)
  - Add: clear(y), holding(x)
  - Del:
- putdown(x)
  - Pre: holding(x)
  - Add: on(x,T), clear(x), empty
  - Del:
- pickup(x)
  - Pre: empty, clear(x), on(x,T)
  - Add: holding(x)
  - Del:

Planning Graph for Relaxed Plan

- **Level 1**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty
  - unstack(a,b), pickup(d)
- **Level 2**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty, holding(a), holding(d), clear(b)
  - stack(a,b), stack(a,d), stack(d,b), unstack(b,c), putdown(a), putdown(d)
- **Level 3**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty, holding(a), holding(d), clear(b), on(a,T), on(d,b), on(a,d), clear(c), holding(b)
  - stack(b,a), stack(b,c), stack(b,d), putdown(b), stack(a,c), stack(d,c), pickup(c)
- **Level 4**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty, holding(a), holding(d), clear(b), on(a,T), on(d,b), on(a,d), clear(c), holding(b) , on(b,T), on(b,a), on(b,c), on(b,d), holding(c), on(d,c), on(a,c)
  - stack(c,a), stack(c,b), stack(c,d), putdown(c)
- **Level 5**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty, holding(a), holding(d), clear(b), on(a,T), on(d,b), on(a,d), clear(c), holding(b) , on(b,T), on(b,a), on(b,c), on(b,d), holding(c), on(d,c), on(a,c), on(c,a), on(c,b), on(c,d)

Computing G_i

- **Level 1**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty
  - unstack(a,b), pickup(d)
- **Level 2**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty, holding(a), holding(d), clear(b)
  - stack(a,b), stack(a,d), stack(d,b), unstack(b,c), putdown(a), putdown(d)
- **Level 3**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty, holding(a), holding(d), clear(b), on(a,T), on(d,b), on(a,d), clear(c), holding(b)
  - stack(b,a), stack(b,c), stack(b,d), putdown(b), stack(a,c), stack(d,c), pickup(c)
- **Level 4**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty, holding(a), holding(d), clear(b), on(a,T), on(d,b), on(a,d), clear(c), holding(b) , on(b,T), on(b,a), on(b,c), on(b,d), holding(c), on(d,c), on(a,c)
  - stack(c,a), stack(c,b), stack(c,d), putdown(c)
- **Level 5**: on(a,b), on(b,c), on(c,T), on(d,T), clear(a), clear(d), empty, holding(a), holding(d), clear(b), on(a,T), on(d,b), on(a,d), clear(c), holding(b) , on(b,T), on(b,a), on(b,c), on(b,d), holding(c), on(d,c), on(a,c), on(c,a), on(c,b), on(c,d)

Goal: on(c,a),on(a,d),on(d,b),on(b,T)

- Computing G_i
  - on(c,a): 5
  - on(a,d): 3
  - on(d,b): 3
  - on(b,T): 4
- So, G_5 = {on(c,a)}, G_4 = {on(b,T)}, G_3 = {on(a,d), on(b,d)}

- i = 4: g = on(c,a)
  - o = stack(c,a)
  - pre(o) = {clear(a), holding(c)}
  - f = holding(c)
  - (Gf) G4 = {on(b,T), holding(c)}
- i = 3: g in G_4
  - o = {putdown(b), pickup(c)}
  - G3 = {holding(b), clear(c), on(a,d), on(b,d)}
- i = 2: g in G_3
  - {unstack(b,c), stack(a,d), stack(d,b)}
- i = 1
  - {unstack(a,b), pickup(d)}
- Plan: 8