人工知能特論： 後ろ戻り探索アルゴリズム (続き)　第 6 回

1. 後ろ戻りアルゴリズム (*Backtrack search algorithms*)

Go back $\longrightarrow$

Go	↓	BT	BJ	CBJ
Forward	↓	BM	BMJ	BM-CBJ
	↓	FC	FC-BJ	FC-CBJ

BackTracking, BackJumping, BackMarking Conflict-directed, Forward Chaining

[文献] G. Kondrak and P. van Beek: A Theoretical Evaluation of Selected Backtracking Algorithms, *Artificial Intelligence*, **89**(1997), 365–387.

FC-CBJ ：*label*

```
function  $fc\text{-}cbj\text{-}label(i)$
  for each $v_k \in CD_i$ do
      Set $x_i = v_k$ and $consistent$ = $true$
      for $j$ from $i+1$ to $n$ do
        if $\neg check\text{-}forward(i,j)$ then
          Remove $v_k$ from $CD_i$ and $consistent$ = $false$
          $undo\text{-}reductions(i)$
          $conf\text{-}set_i$ = $conf\text{-}set_i \cup past\text{-}fc_j$
          Unassign $x_i$ and break inner loop
        endif
      endfor
      if $consistent$ then return $(i+1, true)$
  endfor
  return $(i, false)$
end  $fc\text{-}cbj\text{-}label$
```

FC-CBJ ：*unlabel*

```
function  $fc\text{-}cbj\text{-}unlabel(i)$
    $h$ = $max(max\text{-}list(conf\text{-}set_i),\ max\text{-}list(past\text{-}fc_i))$
    $conf\text{-}set_h$ = $(conf\text{-}set_h \cup conf\text{-}set_i \cup past\text{-}fc_i) \setminus \{h\}$
    for $j$ from $i$ downto $h+1$ do
        $conf\text{-}set_j$ = $\{0\}$
        $undo\text{-}reductions(j)$
        $undate\text{-}current\text{-}domain(j)$
    endfor
    $undo\text{-}reductions(h)$
    Remove current value assigned to $x_h$ from $CD_h$
    Unassign $x_h$
    if $CD_h$ is empty then return （$h$, $false$） /* 行止り */
    else                    return （$h$, $true$） /* 次の値 */
end  $fc\text{-}cbj\text{-}unlabel$
```

The Zebra Problem

There are five houses with five different colours, in each house lives a person of different nationalityhaving favorite drinks, cigaretes and pets, the information is:

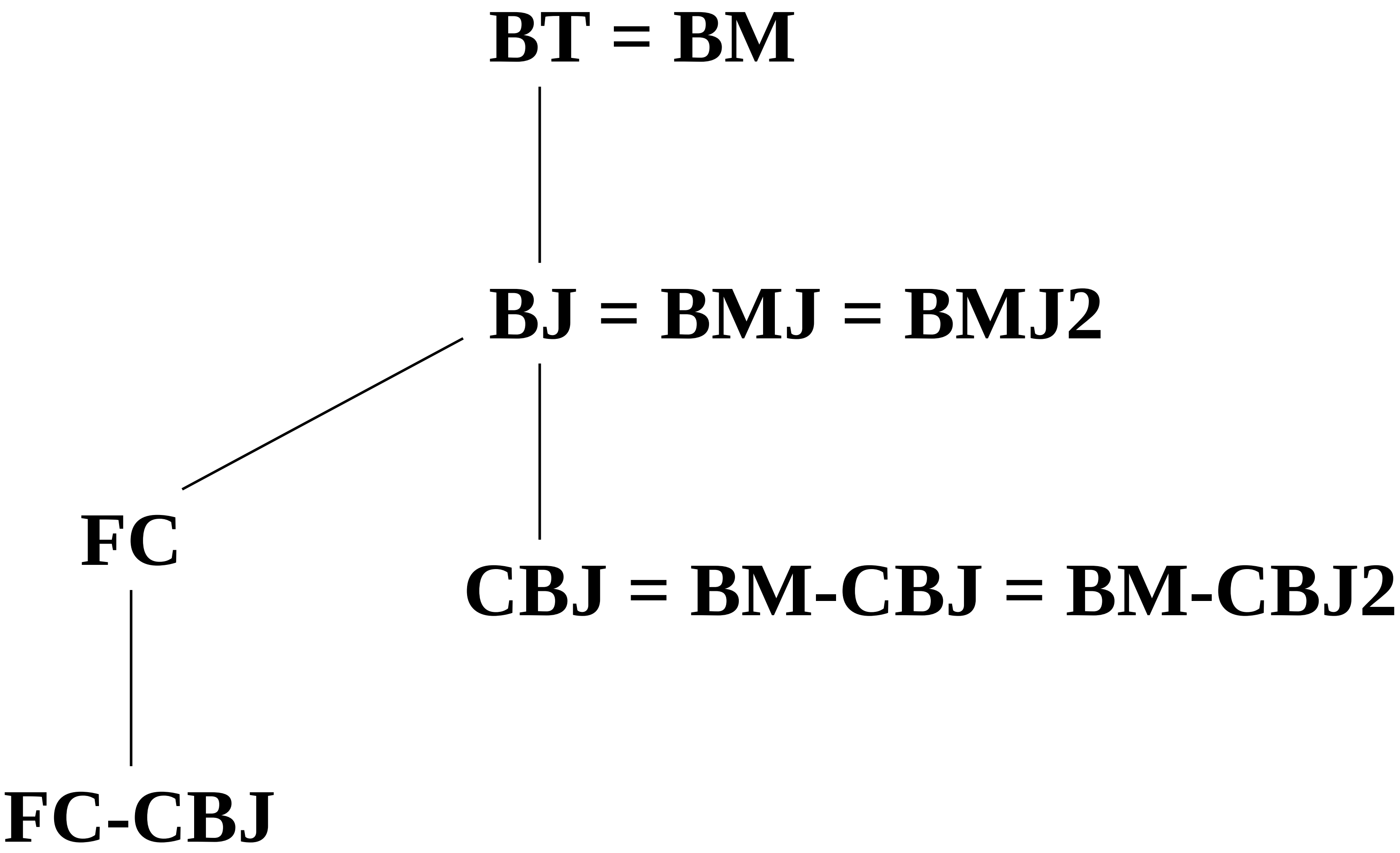
- The *Englishman* lives in the *Red* house
- The *Spaniard* owns the *dog*
- The *Norwegian* lives in the *first house on the left*
- *Kools* are smoked in the *Yellow* hmbixouse
- The man who smokes *Chesterfields* lives in the *house next* to the man with the *fox*.
- The *Norwegian* lives next to the *Blue* house
- The *Winston* smoker owns *snails*.
- The *Lucky Strike* smoker drinks *orange juice*
- The *Ukrainian* drinks *tea*
- The *Japanese* smokes *Parliaments*
- *Kools* are smoked in the house *next to the house* where the *horse* is kept
- *Coffee* is drunk in the *Green* house
- The *Green* house is *immediately to the right* (your right) of the *Ivory* house item *Milk* is drunk in the *middle* house.

The Zebra Problem (Cont'd)

Problem : Where does the *Zebra* live, and in which house do they drink *water* ?

House	Pet	Drink	Nationality	Cigaretts

訪問するノード数による後ろ戻り法の階層



BT = BM

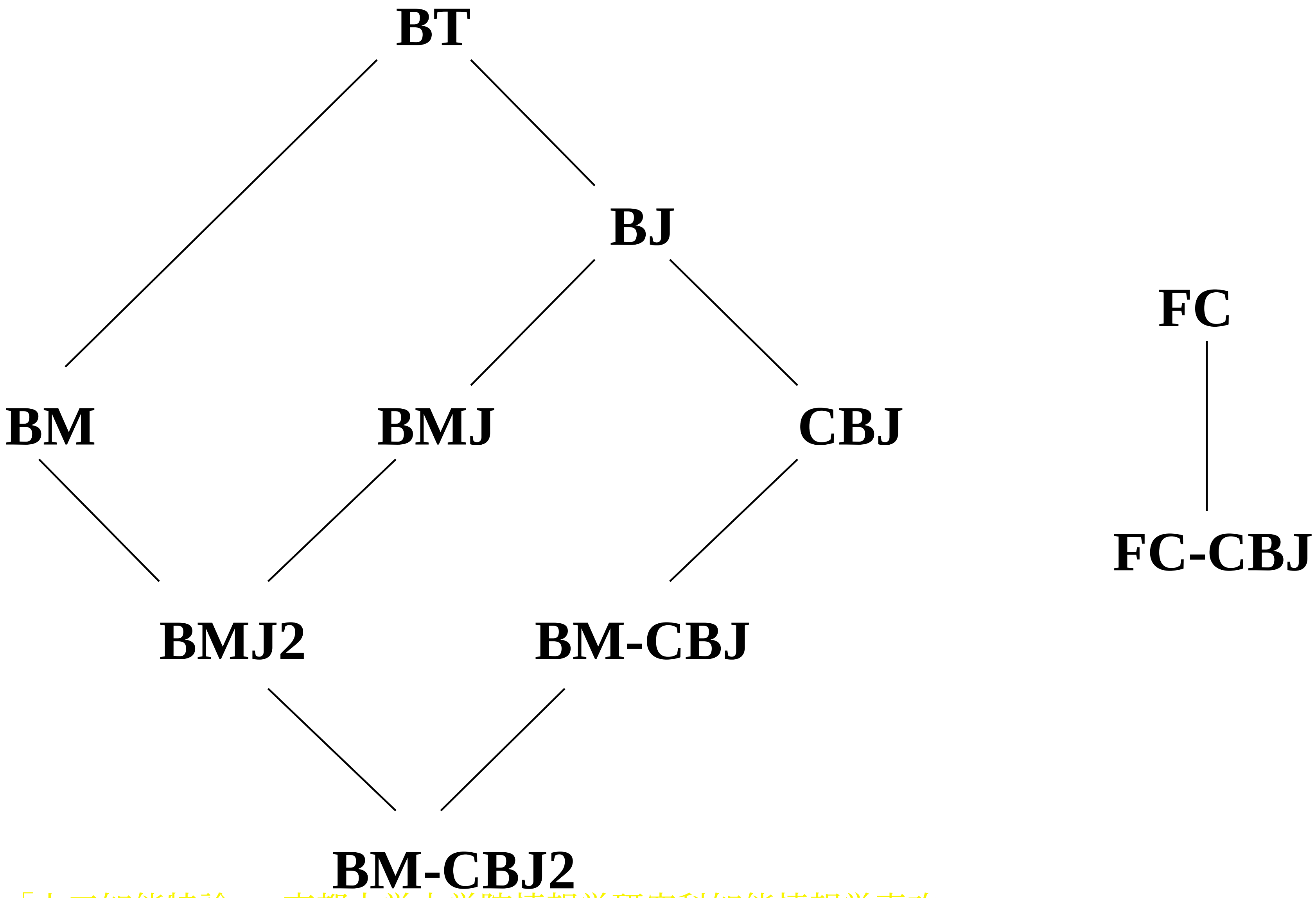
BJ = BMJ = BMJ2

FC

CBJ = BM-CBJ = BM-CBJ2

FC-CBJ

制約チェック回数による後ろ戻り法の階層



動的な変数順序

1. 変数順序を固定すると、深さ i の変数は常に x_i
2. 変数順序を動的にすると，この仮定は成立せず

$\Longrightarrow$ 探索木の **ノード** と**変数**とを明確に区別する必要がある.

- アルゴリズムの各ステップがループするのが，ノードなのか変数なのかを区別する

データ構造

1. nd_i
   - レベル i での探索ノード
   - $nd_i \cdot var$ はレベル i での変数のインデックス
   - $Con(i, j)$ はノード nd_i と nd_j に割り当てられた値間の制約チェック
2. cl
   - 探索木の現在のレベル
   - nd_{cl} ： 現在のレベルでのノード
3. $unassigned$
   - 割り当てられていない変数のインデックス

動的変数順序を用いた時間的後戻り ：*label*

```
function  $btvar\text{-}label(i)$
 $nd_{cl}\cdot var = i$ and $unassigned = unassigned \setminus \{i\}$
  for each $v_k \in CD_i$ do
        Set $x_i = v_k$ and $consistent = true$
        for $j$ from $1$ to $cl - 1$ do
          if $\neg check\text{-}forward(i, j)$ then
            Remove $v_k$ from $CD_i$ and $consistent = false$
            $undo\text{-}reductions(i)$
            $conf\text{-}set_i = conf\text{-}set_i \cup past\text{-}fc_j$
            Unassign $x_i$ and break inner loop
          endif
        endfor
        if $consistent$ then return $(i + 1,\ true)$
  endfor
  return $(i,\ false)$
end  $ftvar\text{-}label$
```