CSP Example.

- There are three **different** musicians: **John, Mark, and Sam.**
- They each come from a **different** country; one comes from the **United States**, one from **Australia**, and one from **Japan**.
- They each play a **different** musical instrument; one plays the **piano**, one the **saxophone**, and one the **violin**.

CSP Example.

- They take turns playing a solo piece of music (that is, they take turns playing alone) and each musician plays a solo only once.

- The **pianist** plays first.

- **John** plays the **saxophone** and plays before the **Australian**.

- **Mark** comes from the **United States** and plays before the **violinist**.

1. What is the order the instruments are played.
2. Who plays what instrument
3. What is the nationality of each player

CSP Example

- Solve this by setting it up as a CSP and then using backtracking search to solve it.

- CSP Formulation
  - Want the order the instruments are played
    - One variable for each instrument **violin, sax, piano**
    - Domain of values for each of these variables = {1, 2, 3}
    - The value indicates the order the instrument is played.
    - E.g., violin = 1 indicates that the violin is played first.

CSP Example

- CSP Formulation
  - Want the order the instruments are played
    - One variable for each instrument **violin, sax, piano**
    - Domain of values for each of these variables = {1, 2, 3}
    - The value indicates the order the instrument is played
    - E.g., violin = 1 indicates that the violin is played first.
  - What about who plays what instrument
    - One variable for each player **john, mark, sam**
    - Domain of values
      - {violin, sax, piano} is intuitive but this won't work in a CSP formulation. Values cannot be variables!
      - Use {1, 2, 3} instead. E.g. **john = 1** indicates that John plays first.
      - A CSP solution is an assignment of every variable. So if in the solution **john = 1** and **piano = 1,** we can conclude that **John plays the piano!**

CSP Example

- CSP Formulation
  - Want the order the instruments are played
    - One variable for each instrument **violin, sax, piano**
    - Domain of values for each of these variables = {1, 2, 3}
    - The value indicates the order the instrument is played.
    - E.g., violin = 1 indicates that the violin is played first.
  - What about who plays what instrument
    - One variable for each player **john, mark, sam**
    - Domain of values
      - {violin, sax, piano} is intuitive but this won't work in a CSP formulation. Values cannot be variables!
      - Use {1, 2, 3} instead. E.g. **john = 1** indicates that John plays first.
      - A CSP solution is an assignment of every variable. So if in the solution **john = 1** and **piano = 1,** we can conclude that **John plays the piano!**
- **Finally** we use the same logic for the countries
  - One variable for each country **aust, us, japan**
  - Domain of values {1, 2, 3}
  - E.g., japan = 1 indicates that the Japanese plays first

CSP Example

- CSP Formulation
  - Variables **john, mark, sam, violin, sax, piano, aust, us, japan.**
  - Domain of each variable = {1, 2, 3}
  - Constraints:
    1. Each musician, instrument, and country is different:
       john ≠ mark, john ≠ sam, sam ≠ mark
       violin ≠ sax, violin ≠ piano, sax ≠ piano
       aust ≠ us, aust ≠ japan, us ≠ japan
    2. The pianist plays first. **Unary constraint.** We can account for that by removing from the domain of **piano** all values that violate the constraint **Dom[piano] = {1}**

CSP Example

- CSP Formulation
  - Variables **john, mark, sam, violin, sax, piano, aust, us, japan.**
  - Domain of each variable = {1, 2, 3}
  - Constraints:

4. **John** plays the **saxophone** and plays before the **Australia**
   4a: john = sax
   4b: john < aust

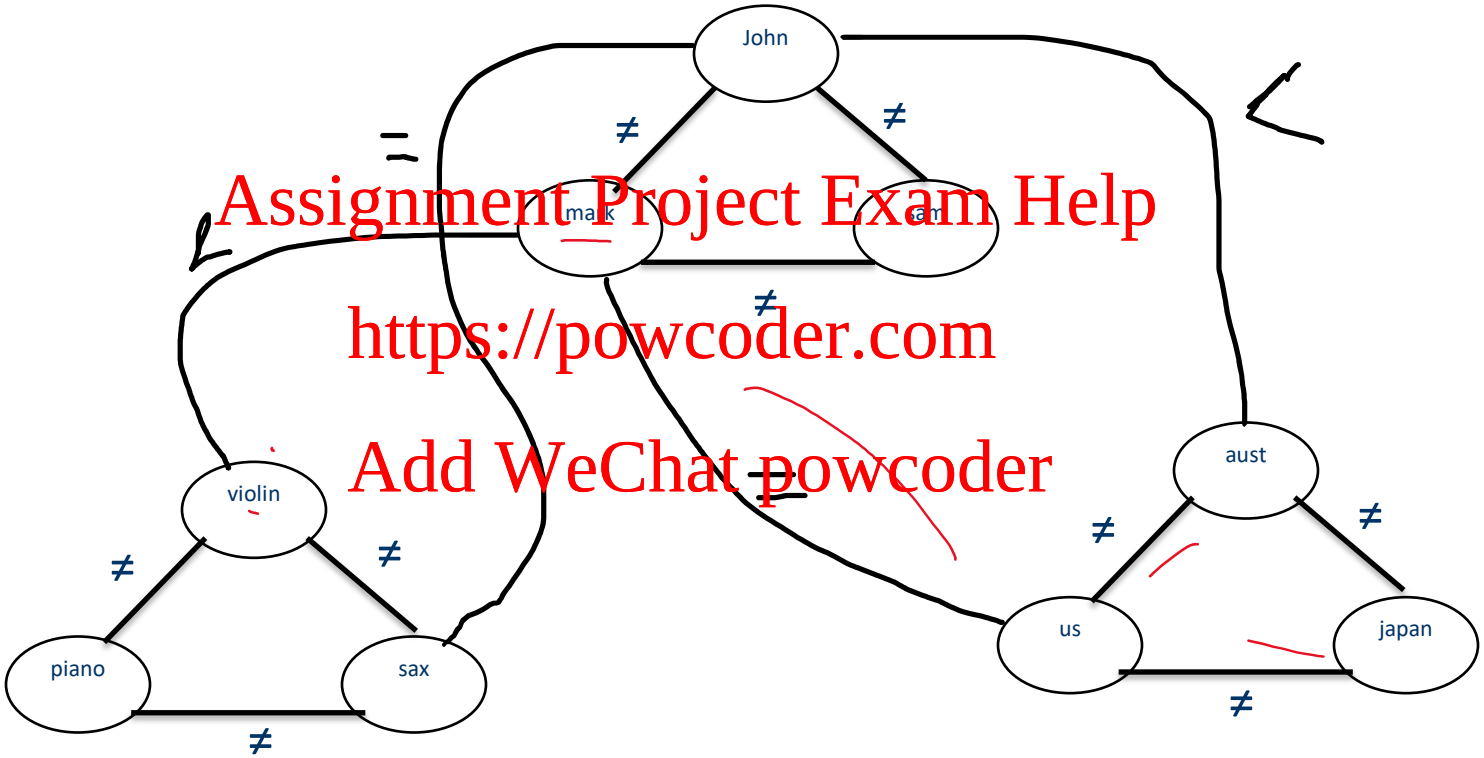
5. **Mark** comes from the **United States** and plays before the **violinist**.
   5a: mark = us
   5b: mark < violin

CSP Example

- CSP Formulation
  - Variables **john, mark, sam, violin, sax, piano, aust, us, japan.**
  - Domain of each variable except piano = {1, 2, 3}
  - Dom**[piano] = {1}**
  - Constraints:

1. **john ≠ mark, john ≠ sam, sam ≠ mark**
2. **violin ≠ sax, violin ≠ piano, sax ≠ piano**
3. **aust ≠ us, aust ≠ japan, us ≠ japan**
4. **john = sax**
5. **john < aust**
6. **mark = us**
7. **mark < violin**

CSP Example



CSP Example

- Solve by Forward Checking (all binary constraints so good for FC) + MRV (minimum remaining values