# LECTURE 11: ARGUMENTATION

An Introduction to Multiagent Systems

CISC 7412, Fall 2011

## Today

- Last week we looked at negotiation.
  - Mechanisms for getting agents to decide how to divide resources.
- This week we'll look at another approach to agreement.
  - Argumentation
- More general approach than negotiation.
  - Come to agreement about anything that can be described by a set of propositions.

# Argumentation

- Argumentation is the process of attempting to agree about what to believe.
- Only a question when information or beliefs are contradictory.
  - If everything is consistent, just merge information from multiple agents.
- Argumentation provides principled techniques for resolving inconsistency.
- Or at least, sensible rules for deciding what to believe in the face of inconsistency.

- Gilbert (1994) identified 4 modes of argument:

  1. *Logical mode* — akin to a proof.
     "If you accept that $A$ and that $A$ implies $B$, then you must accept that $B$".
  2. *Emotional mode* — appeals to feelings and attitudes.
     "How would you feel if it happened to you?"
  3. *Visceral mode* — physical and social aspect.
     "Cretin!"
  4. *Kisceral mode* – appeals to the mystical or religious
     "This is against Christian teaching!"

- Depending on circumstances, some of these might not be accepted.

- For example, can dispute forms of logical inference.
  - Law of excluded middle/Intuitionism
  - Modus tollens
- Lewis Carroll's "What the Tortoise Said to Achilles"

`http://www.ditext.com/carroll/tortoise.html`

## Abstract Argumentation

- Concerned with the overall structure of the set of arguments
  - Rather than internals of individual arguments.
  - We'll get to the internals later.
- Write $x \rightarrow y$
  - "argument $x$ attacks argument $y$";
  - "$x$ is a counterexample of $y$; or
  - "$x$ is an attacker of $y$".

where we are not actually concerned as to what $x$, $y$ are.

- In case this seems too abstract, here are some arguments we'll be looking at.

  $p$ : Since the weather today is sunny, I'm going to go out on my bike.

  $q$ : Since today is a weekday and I have to go to work, I can't go out on my bike.

  $r$ : Since today is a holiday, I don't have to go to work.

  $s$ : Since I took the day off, I don't have to go to work.

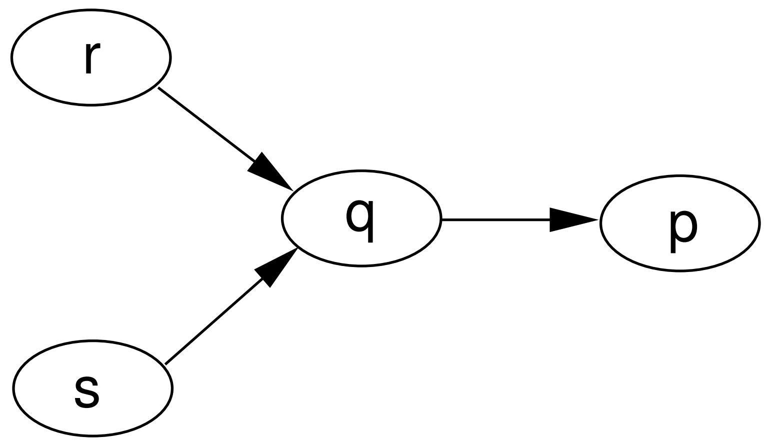
- Without getting too specific, we can see (hopefully) that there is a conflict between some of these arguments.

- An *abstract argument system* is a collection or arguments together with a relation "$\rightarrow$" saying what attacks what.
- Systems like this are called *Dung-style* (or Dungian) after their inventor.

- A set of Dung-style arguments:

$$\langle \{p, q, r, s, \}, \{(r, q), (s, q), (q, p)\}\rangle$$

meaning that $r$ attacks $q$, $s$ attacks $q$ and $q$ attacks $p$.




- The question is, given this, what should we believe?

## Preferred extensions

- There is no universal agreement about what to believe in a given situation, rather we have a set of criteria.
- A *position* is a set of arguments.
  - Think of it as a viewpoint
- A position $S$ is *conflict free* if no member of $S$ attacks another member of $S$.
  - Internally consistent
- The conflict-free sets in the previous system are:

$$\emptyset, \{p\}, \{q\}, \{r\}, \{s\}, \{r, s\}, \{p, r\}, \{p, s\}, \{r, s, p\}$$

- If an argument $a$ is attacked by another $a'$, then it is *defended* by $a''$ if $a''$ attacks $a'$.
- Thus $p$ is defended by $r$ and $s$.

- A position $S$ is *mutually defensive* if every element of $S$ that is attacked is defended by some element of $S$.
  - Self-defence is allowed
- These positions are mutually defensive:

$$\emptyset, \{r\}, \{s\}, \{r,s\}, \{p,r\}, \{p,s\}, \{r,s,p\}$$

- A position that is conflict free and mutually defensive is *admissible*.
- All the following positions are admissible.

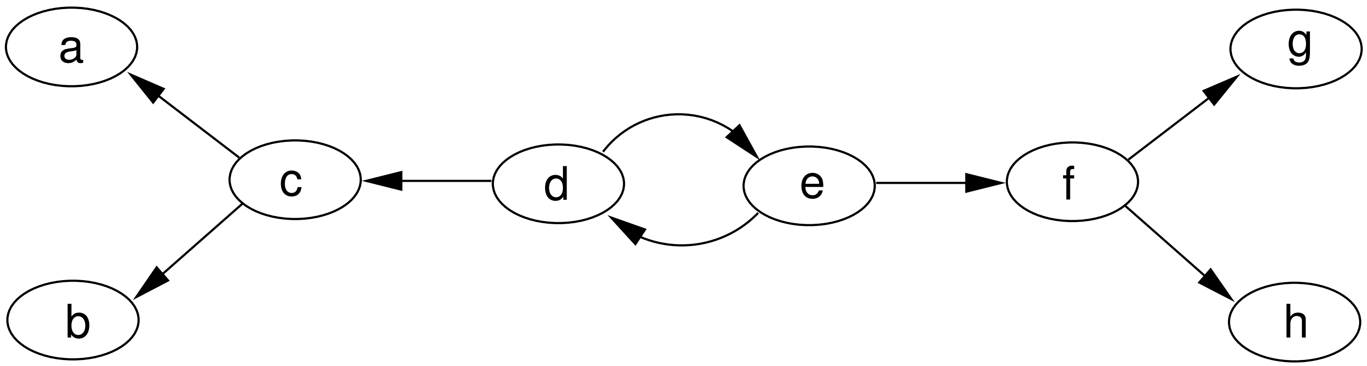
$$\emptyset, \{r\}, \{s\}, \{r, s\}, \{p, r\}, \{p, s\}, \{r, s, p\}$$

- Admissibility is a minimal notion of a reasonable position — it is internally consistent and defends itself against all attackers.

- A *preferred extension* is a maximal admissible set.
  - adding another argument will make it inadmissible.
- In other words $S$ is a preferred extension if $S$ is admissible and no superset of $S$ is admissible.
- Thus $\emptyset$ is not a preferred extension, because $\{p\}$ is admissible.
- Similarly, $\{p, r, s\}$ is admissible because adding $q$ would make it inadmissible.

- A set of arguments always has a preferred extension, but it may be the empty set.

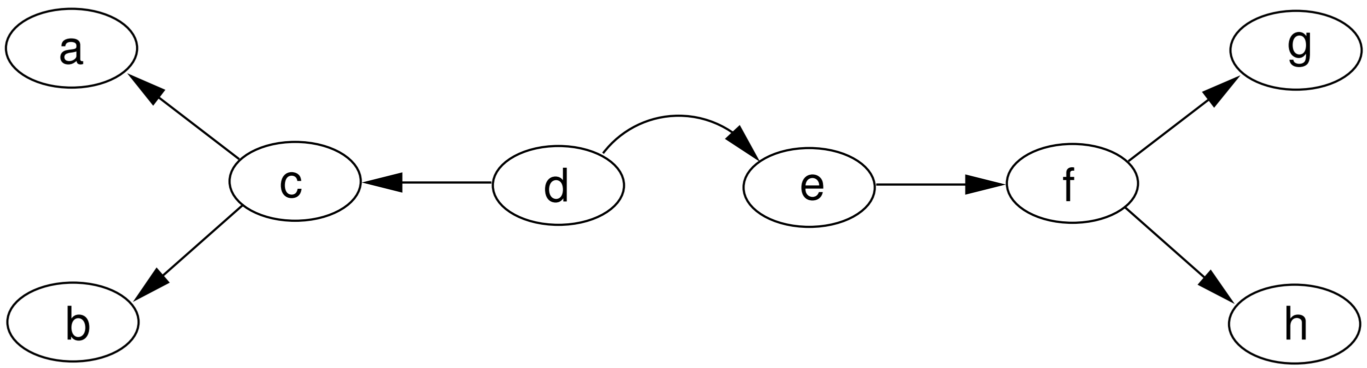
- With a larger set of arguments it is exponentially harder to find the preferred extension.
- $n$ arguments have $2^n$ possible positions.
- This set of arguments:




has two preferred extensions:

$$\{a, b, d, f\} \qquad \{c, e, g, h\}$$

- In contrast:

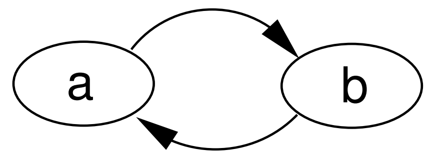



has only one:

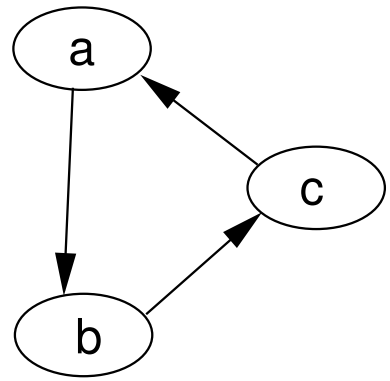
$$\{a, b, d, f\}$$

since $c$ and $e$ are now attacked but undefended, and so can't be in an admissible set.

- Two rather pathological cases are:




with preferred extensions $\{a\}$ and $\{b\}$, and:




which has only $\emptyset$ as a preferred extension.

- The issue with multiple extensions is that we have no way of saying which extension is best.
- Tells us what we might reasonably believe, but not what we should believe.

## Credulous and sceptical acceptance

- To improve on preferred extensions we can define

  An argument is sceptically accepted if it is a member of *every* preferred extension.

  and

  An argument is credulously accepted if it is a member of *at least one* preferred extension.

- Clearly anything that is sceptically accepted is also credulously accepted.

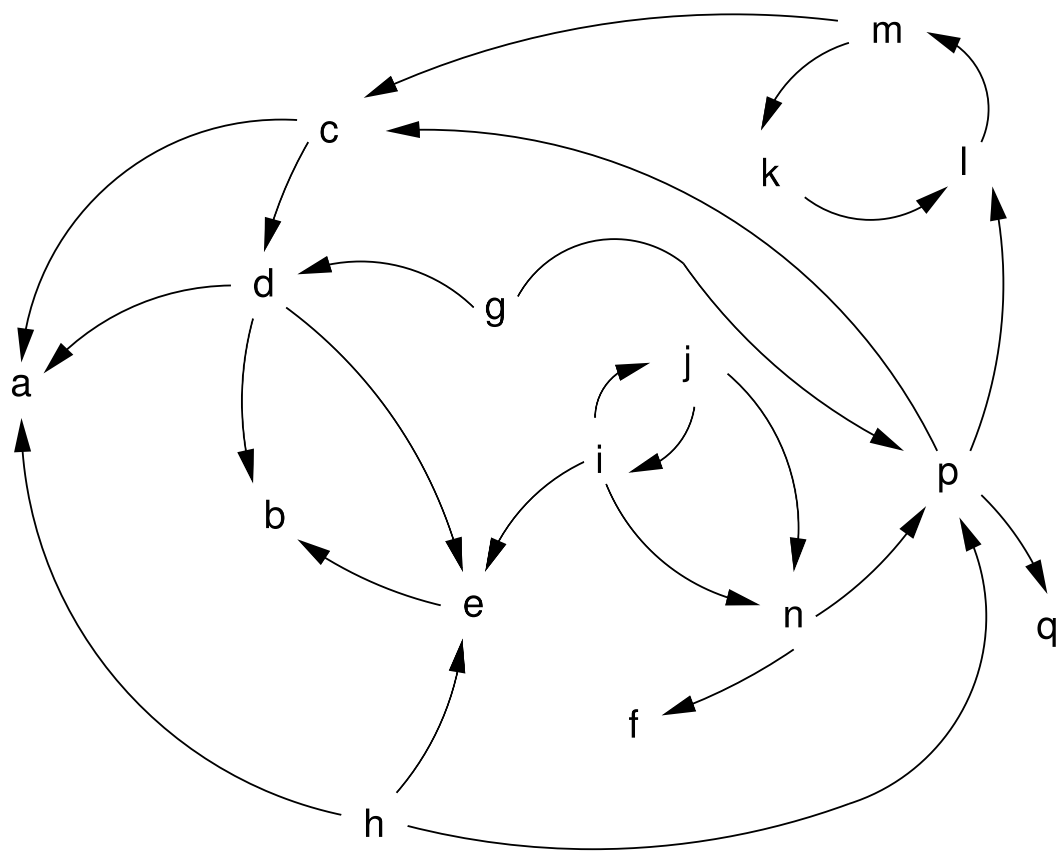
- Can think of arguments in sceptical extensions as being more believable than those in sceptical extensions.
- And those in sceptical extensions as being more beleivable than those in no extension.

- On our original example, $p$, $q$ and $r$ are all sceptically accepted, and $q$ is neither sceptically or credulously accepted.

## Grounded extensions

- Another approach, perhaps better than preferred extension.
- Arguments are guaranteed to be acceptable if they aren't attacked.
  - No reason to doubt them
- They are IN
- Once we know which these are, any arguments that they attack must be unacceptable.
- They are OUT — delete them from the graph.
- Now look again for IN arguments. . .
- And continue until the graph doesn't change.
- The set of IN arguments make up the *grounded extension*.

- Consider computing the grounded extension of:

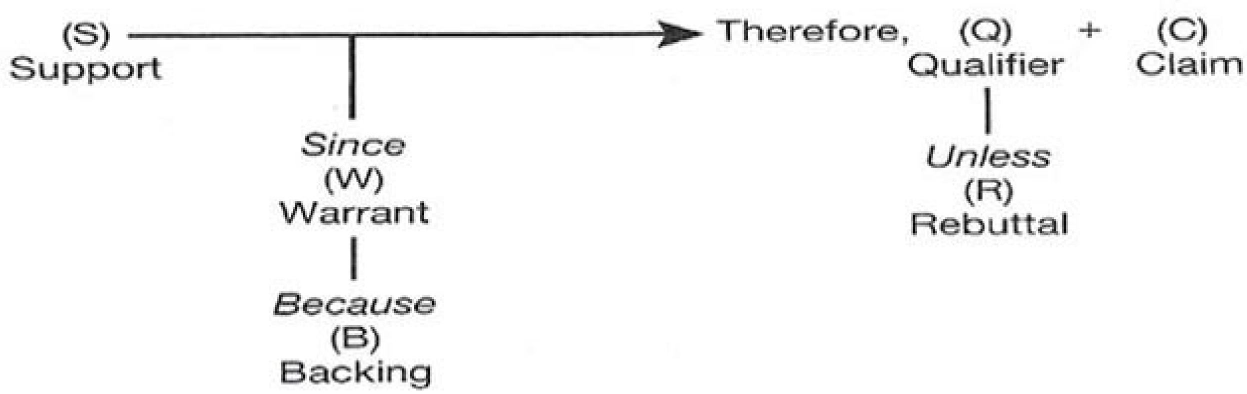


- We can say that:
  - $h$ is not attacked, so IN.
  - $h$ is IN and attacks $a$, so $a$ is OUT.
  - $h$ is IN and attacks $p$, so $p$ is OUT.
  - $p$ is OUT and is the only attacker of $q$ so $q$ is IN.

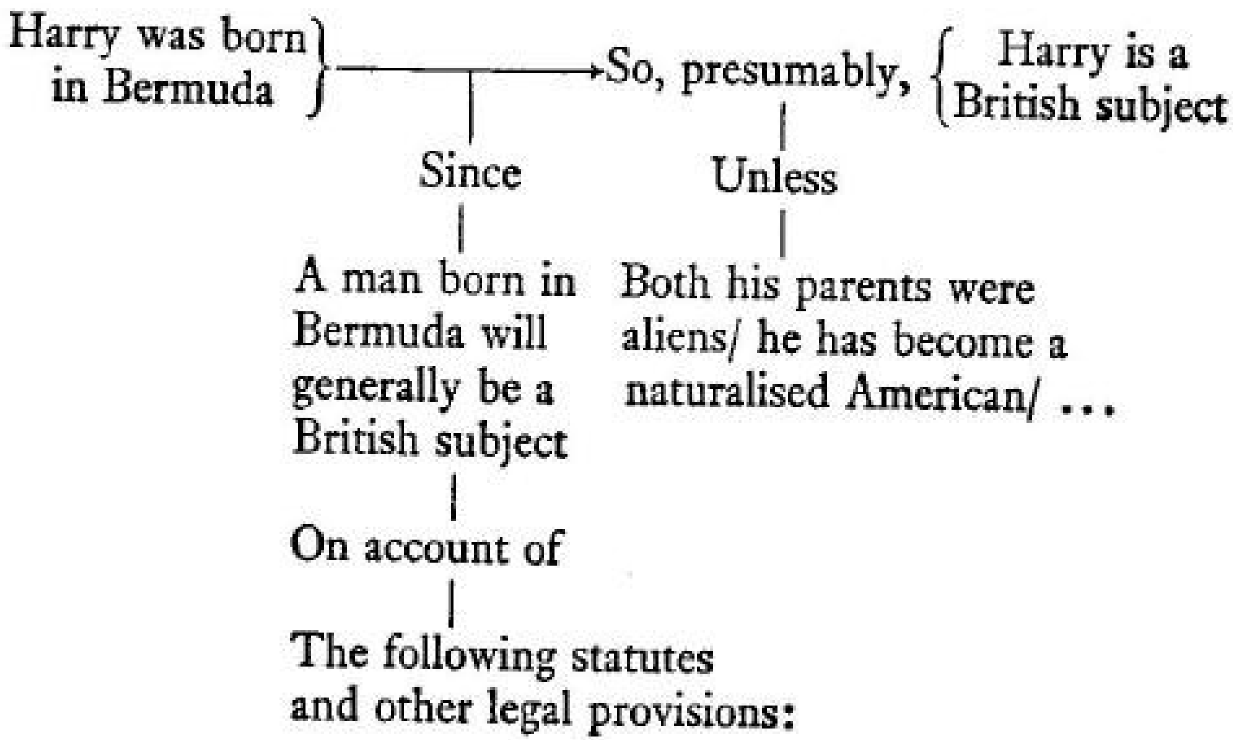
- There is always a grounded extension, and it is always unique (though it may be empty)

# Deductive Argumentation

- Argumentation models *defeasible reasoning*.




- Conclusions can be rebutted, premises (and warrants) can be challenged.


Harry was born in Bermuda
So, presumably, Harry is a British subject
Since
Unless
A man born in Bermuda will generally be a British subject
Both his parents were aliens/ he has become a naturalised American/ ...
On account of
The following statutes and other legal provisions:

# Deductive Argumentation

Basic form of deductive arguments is as follows:

$$\Sigma \vdash (S, p)$$

where:

- $\Sigma$ is a (possibly inconsistent) set of logical formulae;
- $p$ is a logical formula known as the *conclusion*; and
- $S$ is a set of logical formulae (the "support") such that:
  1. $S \subseteq \Sigma$;
  2. $S \vdash p$; and
  3. There is no $S' \subset S$ such that $S' \vdash p$.
- Often we just write the argument as $(S, p)$.

# Attack and Defeat

- Argumentation takes into account the relationship between arguments.
- Let $(S, p)$ and $(S', p')$ be arguments from some database $\Sigma$
- Then $(S, p)$ can be attacked in one of two ways:

1. $(S', p')$ *rebuts* $(S, p)$ if $p' \equiv \neg p$.
2. $(S', p')$ *undercuts* $(S, p)$ if $p' \equiv \neg s$ for some $s \in S$.

- Deductive argumentation connects to the asbtract ideas we were just looking at.
- A rebuttal or undercut between two arguments becomes the *attack* in a Dungian system.
- Note that a rebut is symmetrical
  - Causes problems with some kinds of extension.
- Once we have identified attacks, we can look at preferred extensions or grounded extensions to determine what arguments to accept.

## Example

- Here is one deductive argument.

  $a$ denotes "We recycle"

  $b$ denotes "We save resources"

  $a \rightarrow b$ denotes "If we recycle, then we save resources"

- Formally we get:

$$(\{a, a \rightarrow b\}, b)$$

- Call this argument $x$.

- A second argument, that conflicts with the first

  $c$ denotes "Recycled products are not used"

  $a \wedge c \rightarrow \neg b$ denotes "If we recycle and recycled products are not used then we don't save resources"

- So we have:

$$(\{a, c, a \wedge c \rightarrow \neg b\}, \neg b)$$

- Call this argument $y$.

- A third argument, that conflicts with the first

  $d$ denotes "We create more desirable recycled products"

  $d \rightarrow \neg c$ denotes "If we create more desirable recycled products then recycled products are used"

- So we have:

$$(\{d, d \rightarrow \neg c\}, \neg c)$$

- Call this argument $z$.

- $x$ and $y$ rebut each other.
- $z$ undercuts $y$.
- What extensions do we have?

# Argument strength

- Build on the basic idea by allowing arguments to have a *strength*.
  - Expressed using an order $\preceq$
- Assume that for every pair of arguments $A_1$ and $A_2$, either $A_1 \preceq A_2$ or $A_2 \preceq A_1$ or both.
  - If both, then the arguments are equally strong.
- Then we say that $A_1$ attacks $A_2$ if $A_1$ rebuts or undercuts $A_2$ *and* $A_2 \preceq A_1$.

# Argumentation and Communication

- We have two agents, $P$ and $C$, each with some knowledge base, $\Sigma_P$ and $\Sigma_C$.
- Each time one makes an assertion, it is considered to be an addition to its *commitment store*, $CS(P)$ or $CS(C)$.
- Commitment stores are information that the agent has made public.
- Thus $P$ can build arguments from $\Sigma_P \cup CS(C)$, and $C$ can use $\Sigma_C \cup CS(P)$.

- We assume that dialogues start with $P$ making the first move.
- The outcomes, then, are:
  - $P$ generates an argument both classify as IN, or
  - $C$ makes $P$'s argument OUT.

## Argumentation Protocol

- A typical persuasion dialogue would proceed as follows:
  1. $P$ has an acceptable argument $(S, p)$, built from $\Sigma_P$, and wants $C$ to accept $p$.
  2. $P$ asserts $p$.
  3. $C$ has an argument $(S', \neg p)$.
  4. $C$ asserts $\neg p$.
  5. $P$ cannot accept $\neg p$ and challenges it.
  6. $C$ responds by asserting $S'$.
  7. $P$ has an argument $(S'', \neg q)$ where $q \in S'$, and challenges $q$.
  8. $\ldots$

## Argumentation Protocol II

- This process eventually terminates when

$$\Sigma_P \cup CS(P) \cup CS(C)$$

  and

$$\Sigma_C \cup CS(C) \cup CS(P)$$

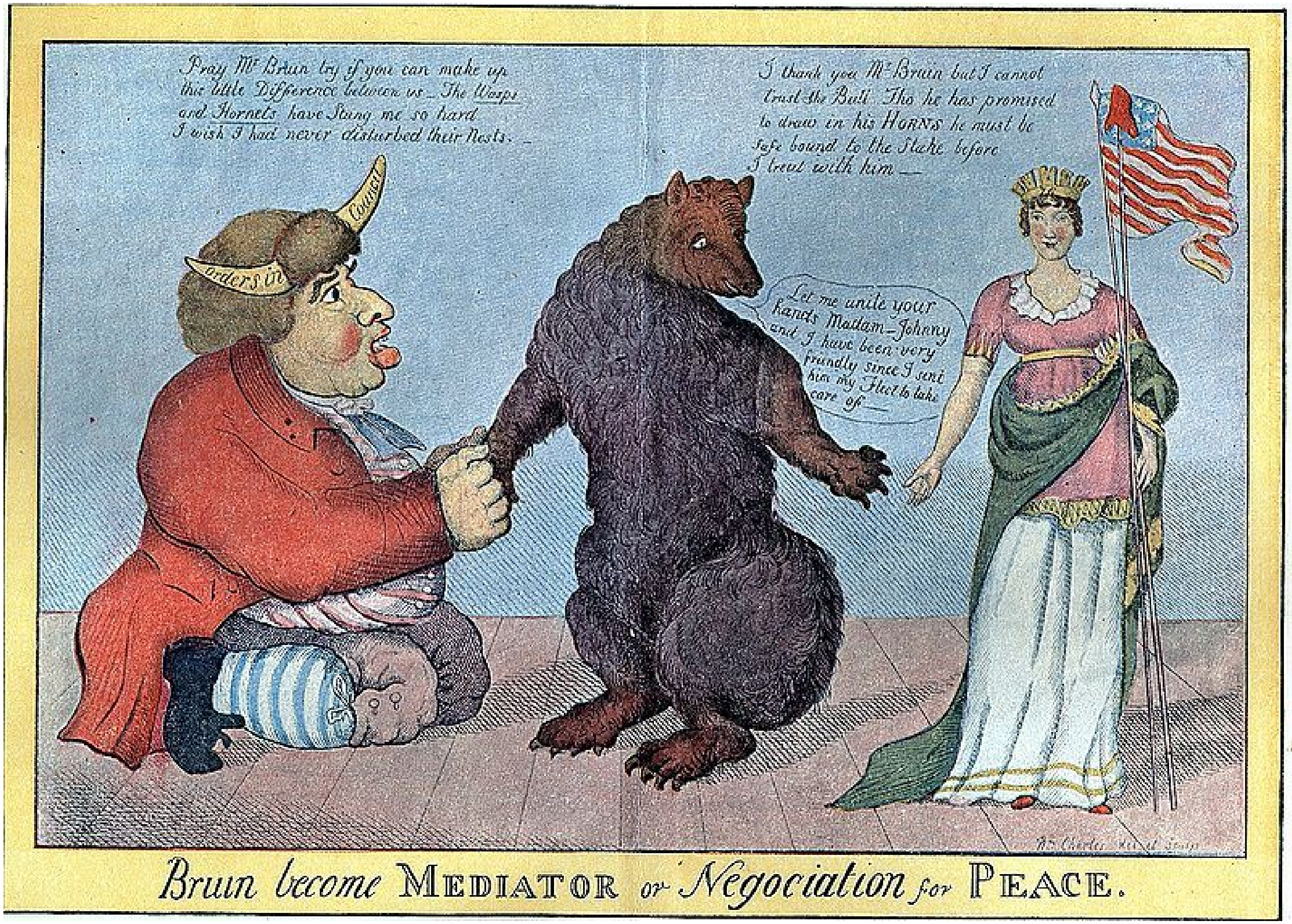
  eventually provide the same set of IN arguments and the agents agree.

- Clearly here we are looking at grounded extensions.

## Different dialogues

- Information seeking
  - Tell me if $p$ is true.
- Inquiry
  - Can we prove $p$?
- Persuasion
  - You're wrong to think $p$ is true.
- Negotiation
  - How do we divide the pie?
- Deliberation
  - Where shall we go for dinner?

- With appropriate choice of language, can use argumentation to capture all of these kinds of dialogue.


Pray Mr. Bruin try if you can make up this little Difference between us – The Wasps and Hornets have Stung me so hard I wish I had never disturbed their Nests. –
orders in Council
I thank you Mr. Bruin but I cannot trust the Bull. Tho he has promised to draw in his HORNS he must be safe bound to the Stake before I treat with him –
Let me unite your hands Madam – Johnny and I have been very friendly since I sent him my Fleet to take care of –
Bruin become MEDIATOR or Negociation for PEACE.

## Summary

- This lecture has looked at argumentation as a means through which agents can reach agreement.
- Argumentation allows for more complex interactions than the negotiation mechanisms we looked at last lecture.
- Argumentation can be used for a range of tasks that include negotiation.
  - Also allows for inquiry, persuasion, deliberation.