Dialogue Manager Tutorial: Part II Theory of Dialogue Manager

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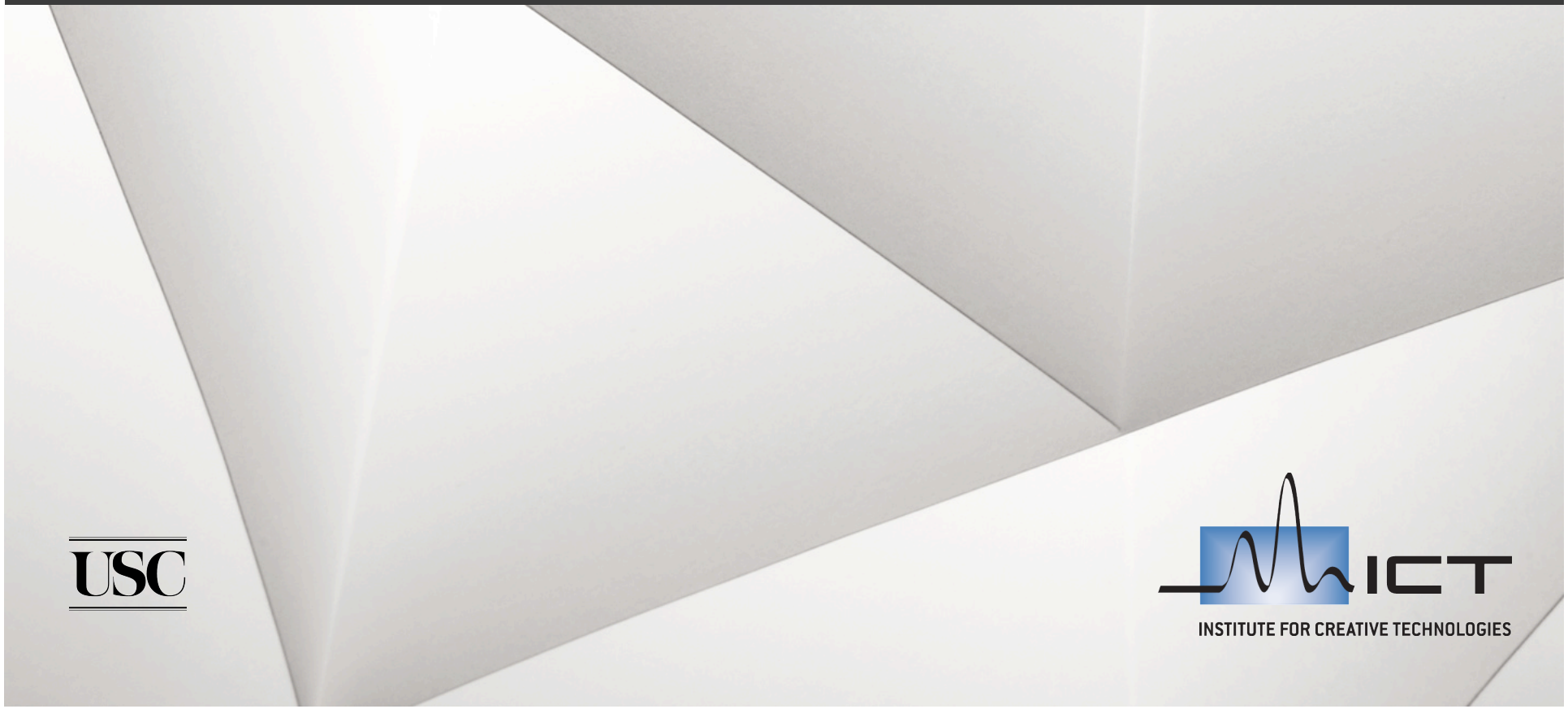

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Elements of Dialogue Theory

- **Cooperation**
- **Obligation & Non-cooperative interaction**
- **Grounding**
- **Multiparty interaction**
- **Cooperative Negotiation**
- **Multiparty Non-Cooperative Negotiation**

Cooperative Dialogue

- **Need to explain: how can independent entities (humans, software agents,…) can coordinate to produce dialogues**
- **Unsatisfactory accounts:**
  - Centralized control
  - Master-slave
  - Pure Reactivity
- **Better:**
  - Rational agency for meaningful action
    - Beliefs, desires, intentions
  - cooperation model to mediate individual interests and group coordination
    - Theory of mind: model of other's agency
    - Reflection and accommodation to desires of other

Use of Cooperative Principles

- Grice ‘75: Maxims, Conversational Implicatures
- Searle ‘75: Indirect Speech acts
- Perrault, Cohen, & Allen 78-83: computational account of speech acts and BDI agency
- Clark & Wilkes-Gibbs 86: Principle of least collaborative effort
- Chu-Carroll & Brown 97: Discourse and Task initiative

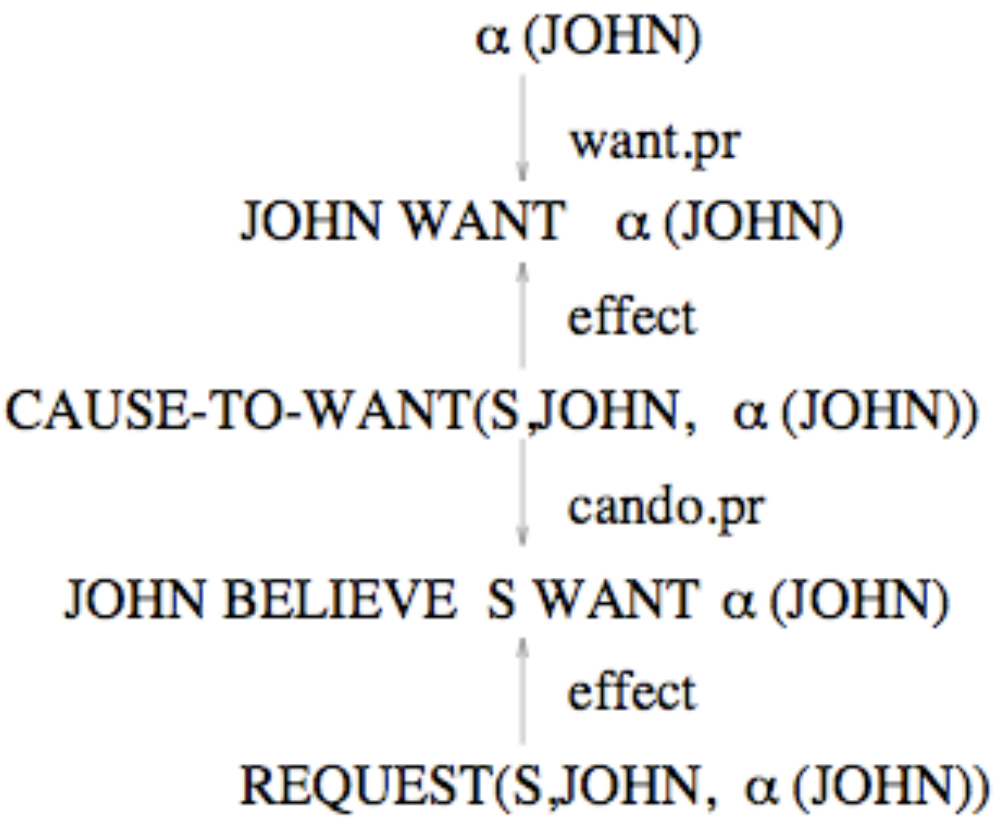
Perrault and Allen (1980)

- **Logic of Beliefs and Wants**
  - Plan operators for speech acts
- **2 levels:**
  - • Illocutionary
  - • surface
- **• Inference rules for construction**
- **• Heuristics for plan expansion**

Perrault and Allen: Hypotheses

1. **Language users are rational agents**
2. **Rational agents can identify actions and goals of others (and sometimes adopt them)**
3. **To successfully perform a speech act, speaker must intend hearer recognize intention to achieve effects of act**
4. **Language users know that others are rational agents**
5. **Speakers can perform one act by performing another, along with expectations of cooperative and rational behavior of others**

Example: Perrault & Cohen '79 Plan for Request



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Allen '83 Speech Act Operators

REQUEST(speaker,hearer,act)

Body: MB(hearer,speaker, speaker WANT hearer DO act)

Effect: hearer WANT hearer DO act

SURFACE-REQUEST(speaker,hearer,act)

Body: imperative utterance from speaker to hearer with semantic content "act"

Effect: MB(hearer,speaker, speaker WANT hearer DO act)

Cooperative Formulations

- **Tuomela & Miller 88, Searle '90: We-Intentions**
- **Cohen & Levesque 91: Joint Intentions**
- **Grosz & Sidner: Shared Plans**
- **Lewis '69 Convention**
- **Kinds of cooperative interaction**
  - Share same goals
  - Compromise/negotiated agreement
  - Nash Equilibrium

Allwood's Ideal Cooperation

(Allwood '76, Allwood et al 2000)

I. **take each other into cognitive consideration**

II. **have a joint purpose**

III. **take each other into ethical consideration**

IV. **trust each other to act in accordance with I – III**

Problems with Cooperative Accounts

- **Cooperation explains some behavior nicely, but what about when cooperation can not be assumed?**
- **People still engage in basic dialogue behavior such as responding to questions, inference about others' mental state**
- **Need more general account of cooperative & non-cooperative conversational behavior**
- **Cooperation should be "value-added" rather than pre-requisite for conversation**

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Non-cooperation I: lack of cognitive cooperation

- **not reasoning about mental state of other**
  - Not considering goals
    - No goals
    - Assume same goals as self
  - Not considering beliefs
    - Assume same as own
    - Not tracking implications of others' belief
  - Not considering rationality for behavior
  - Not considering emotions

Non-Cooperation II: No Joint purpose

- **Lack of mutuality of purpose**
- **Lack of same purpose**
- **Different purposes**
- **Conflicting purposes**
- **Zero-sum utilities**
- **Antagonism**
- **Retribution/punishment**

Non-Cooperation III: lack of ethical consideration

- **Force/compel behavior, constrict options, coercion**
- **Prevent others from pursuing own motives**
  - Hurt
  - Withhold goals of other
- **Not allow someone to be a rational agent**
  - Give inaccurate information
  - Prevent reasoning
- **Don't satisfy obligations towards other**
- **Prevent other from fulfilling obligations**

Non-Cooperation IV: lack of trust

- **No trust that other will act rationally**
- **No trust that other will cognitively consider self**
- **No trust that other will act according to joint purpose**
- **No trust that other will act ethically (toward self)**
  - No trust that other will fulfill obligations
  - No trust that other will tell truth
  - No trust that other will not hurt
  - No trust that other will allow self to act as agent

Non-cooperative Dialogue Agent Types

- **Intelligent Tutoring Systems (e.g. Zinn et al 2002, Buckley & Wolska)**
  - Follow own goals rather than obligations imposed by student
    - Arguably ultimately cooperative - good of student (education) trumps desires of student and perhaps agentivity
- **Commercial agents (e.g. Jameson et al 1994, Jameson & Weiss 1995)**
  - Competitive goals, perhaps lie or at least mislead
    - Ideally negotiate a compromise price
- **Personal assistants talking to others (e.g., Companions project?)**
  - Follow goals/obligations of owner rather than other conversant
- **Role-playing agents (e.g. Traum et al 2007, Traum et al 2008)**
  - Some roles are non-cooperative

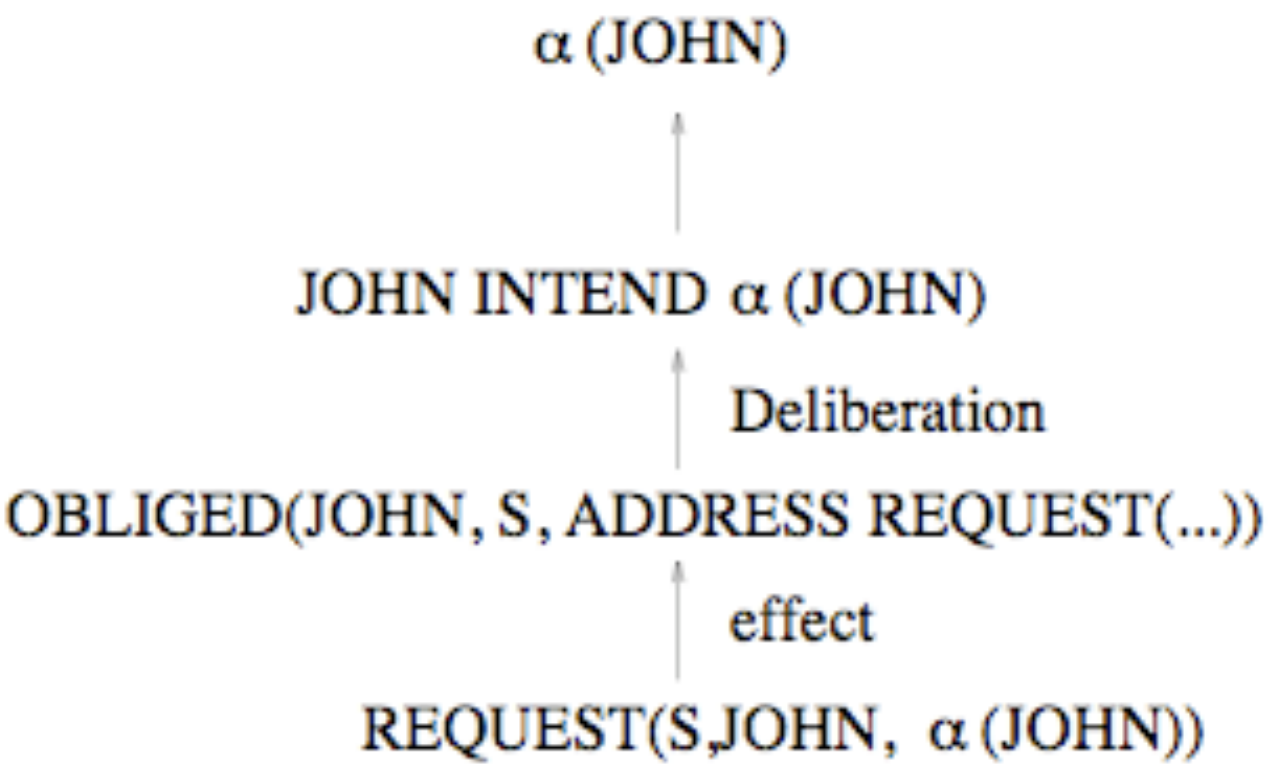
Elements of Solution: multiple mechanisms

- **Agent's motivating factors**
  - Goals
  - (habit?)
  - Obligations
  - Empathy/Altruism
- **When factors coincide: cooperation**
- **When factors conflict: deliberation, choice**
  - Possibly cooperative based on outcome of deliberation
- **Deliberation mechanism: personality profiles & meta-goals**
  - Strength of individual factors
  - Weights of individual factors
  - Power and relative status
  - Social goals

Obligations: Traum & Allen 94

source of obligation	obliged action
S_1 Accept or Promise A	S_1 achieve A
S_1 Request A	S_2 address Request: accept A **or** reject A
S_1 YNQ whether P	S_2 Answer-if P
S_1 WHQ P(x)	S_2 Inform-ref x
utterance not understood or incorrect	repair utterance

Traum & Allen 94: Request model



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What is Grounding?

- Not electrical grounding
- Not postponing space shuttle flights
- Not crashing a ship onto land
- Not symbol-grounding
- Establishing common ground **(Clark & Wilkes-Gibbs '86)**

Grounding

- Common Ground
  - How do we model it?
  - How do we achieve it?
- Grounding Models
  - Clark & Schaefer
  - Traum 94
- Grounding & Media

Styles of Response

1	**Sys:**	Where do you want to go?
2	**User:**	Boston.
3a	**Sys:**	When would you like to go?
3b		Tell me more about your travel plans.
3c		When would you like to go to Boston?
3d		Do you want to go to Boston?
3e		Did you say Boston?
3f		Boston?
3g		Boston or Austin?
3h		Where?
3i		Please Repeat.

Models of Common Ground (MK, MB,…)

- **Iterated (Schiffer 72)**
  - $K_s p \wedge K_A p \wedge K_s K_A p \wedge K_A K_s p \wedge K_s K_A K_s p \wedge \ldots$
- **Fixed Point (Harman 77): "A group of people have mutual knowledge of *p* if each knows *p and we know this*, where *this* refers to the whole fact known"**
- **Shared Situation (Lewis 69): Let us say that it is *common knowledge* in a population P that X if and only if some state of affairs A holds such that:**
  1. Everyone in P has reason to believe that A holds.
  2. A indicates to everyone in P that everyone in P has reason to believe that A holds.
  3. A indicates to everyone in P that X.
- **Primitive Attitude**
- **One-sided (e.g., Cohen '78 BMB)**

How is Common Ground Achieved/Assumed?

- **Iterated: proof of individual attitudes**
  - Truncation heuristics
  - Circular pointer in deepest beliefs (Cohen 78)
- **Shared Situation**
  - Observation of situation
  - Assumptions of sharedness (Clark & Marshall)
- **Grounding**
  - Feedback process

Types of Feedback (Allwood et al 92)

- **Levels:**
  - Contact
  - Perception
  - Understanding
  - Attitudinal Reaction
- **Signals types**
  - Request feedback
  - Prepare other
  - Provide
    - Positive
    - negative

Clark & Schaefer's contribution model

- **Contributions to dialogue are collaborative achievements composed of two phases:**
  - Presentation Phase: A presents utterance **u** for B to consider. He does so on the assumption that, if B gives evidence **e** or stronger, he can believe that B understands what A means by **u**
  - Acceptance Phase: B accepts utterance **u** by giving evidence **e'** that he believes he understands what A means by **u.** He does so on the assumption that, once A registers evidence **e'**, he will also believe that B understands.

Contribution Model

- **Each signal is also a presentation to be grounded**
  - Recursive model
- **Grounding Criterion: ``The contributor and the partners mutually believe that the partners have understood what the contributor meant to a criterion sufficient for the current purpose''**
- **Graded Evidence:**
  - Display
  - Demonstration
  - Acknowledgement
  - Initiation of next relevant contribution
  - Continued attention

Deficiencies of Contribution Model

- **Off-line model**
  - No way to tell recursion has finished until after the fact
  - No clear specification of moves (for interpretation & generation)
  - Not predictive of next utterances
- **Issues with types of evidence**

Computational Model (Traum 94)

- **Contribution recast as "DU" (Discourse Unit)**
  - (later "CGU": common ground unit)
- **Finite state network for CGU, tracking state of groundedness**
- **Set of Grounding acts to affect contents and state**
- **Interpretation and generation rules**

Grounding Acts

Label	Description
initiate	Begin new DU, content separate from previous uncompleted DUs
continue	same agent adds related content to open DU
acknowledge	Demonstrate or claim understanding of previous material by other agent
repair	Correct (potential) misunderstanding of DU content
Request Repair	Signal lack of understanding
Request Ack	Signal for other to acknowledge
cancel	Stop work on DU, leaving it ungrounded and ungroundable

Grounding Automaton

State	Entering Act	Preferred Exiting Act
S	———	Initiate^{I}
1	Initiate^{I}	Ack^{R}
2	ReqRepair^{R}	Repair^{I}
3	Repair^{R}	Ack^{I}
4	ReqRepair^{I}	Repair^{R}
F	$\text{Ack}^{\{I,R\}}$	$\text{Initiate}^{\{I,R\}}$ (next DU)
D	$\text{Cancel}^{\{I,R\}}$	$\text{Initiate}^{\{I,R\}}$ (next DU)

Next Act	In State						
	S	1	2	3	4	F	D
initiate^{I}	1						
continue^{I}		1			4		
continue^{R}			2	3			
repair^{I}		1	1	1	4	1	
repair^{R}		3	2	3	3	3	
ReqRepair^{I}			4	4	4	4	
ReqRepair^{R}		2	2	2	2	2	
ack^{I}				F	1	F	
ack^{R}		F	F			F	
ReqAck^{I}		1				1	
ReqAck^{R}				3		3	
cancel^{I}		D	D	D	D	D	
cancel^{R}			1	1		D	

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Grounding Example: Trains Domain

(1)

1	I: Move the boxcar to Corning
2	I: and load it with oranges
3	R: ok

(2)

1	I: Move the boxcar to Corning
2	R: ok
3	I: and load it with oranges
4	R: ok

(3)

utt:	Grounding Act	DU1
1:	$\text{init}^{\text{I}}(1)$	1
2:	$\text{cont}^{\text{I}}(1)$	1
3:	$\text{ack}^{\text{R}}(1)$	F

(4)

utt:	Grounding Act	DU1	DU2
1:	$\text{init}^{\text{I}}(1)$	1	
2:	$\text{ack}^{\text{R}}(1)$	F	
3:	$\text{init}^{\text{I}}(2)$	F	1
4:	$\text{ack}^{\text{R}}(2)$	F	F

Grounding Example: Trains Domain

UU#	Speaker: Utterance		Act(s)	DU States 1	2	3	4
3.3	M: let's see	:	$init_1$	1			
3.4	: where are there oranges	:	$cont_1$	1			
4.1	S: the oranges are in the warehouse	:	ack_1,$init_2$	F	1		
4.2	: at Corning	:	$cont_2$	F	1		
5.1	M: oh okay	:	ack_2	F	F		
5.2	: and I see that there's a tanker car there	:	$init_3$	F	F	1	
5.3	: oh we don't want a tanker car do we	:	$cancel_3$	F	F	D	
5.4	: um	:		F	F	D	
5.5	: I have to get a boxcar	:	$init_4$	F	F	D	1
5.6	: to Corning	:	$cont_4$	F	F	D	1
5.7	: and then I have to load it with oranges and eventually I have to get that to Bath	:	$cont_4$	F	F	D	1
5.8	: by 8 o'clock	:	$cont_4$	F	F	D	1
6.1	S: right	:	ack_4	F	F	D	F

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Open Problems with this Model

- **Binary grounded/ungrounded decision**
  - No levels of "groundedness" (Roque 2009)
- **Leaves the unit size unspecified**
- **Confusability of grounding acts**
  - e.g. repetition = acknowledgment, repair, or request for repair?
- **Only well-suited for spoken language grounding**

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- Grounding
-
- **Multiparty interaction**
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Aspects of MRE Dialogue

- **Multimodal:**
  - Face To Face (speech+gesture), Radio
  - Speaking modes (shouting, normal, whispering)
- **Interleaved communication and action**
  - Communication to support action (orders, negotiation)
  - Actions to support communication (contact, turn-taking)
  - Actions as communication (acting on an order as grounding order)
- **Multiple Interactors**
  - Messages tailored for multiple addressees/overhearers
- **Multiple Conversations**
  - LT With base/other platoon about arrival time, medevac
  - LT With Sgt, Medic about local area/platoon orders
  - SGT with troops to carry out orders

Dialogue issues

- **Participation Roles**
  - Speaker ID
  - Addressee ID
  - Participant status
- **Multiple conversations & threads**
- **Channel management**
- **Turn-taking**
- **Initiative**
- **Obligations**
- **Grounding**
- **Attention**

Participant Roles (Goffman 74, 81, Clark 96)

- ***Speaker*** **&** ***Hearer*** **are really complex composites**
  - Not individual roles
  - Different kinds of participant status
    - Different rights and responsibilities & actions

Speaker sub-roles

- Roles
  - Composer
  - Performer
  - Responsible Agent
  - Ratified/unratified
- Examples of split roles
  - Author/performer
  - Speechwriter/politician
  - Foreign language speaker/interpreter
  - Copywriter/spokesman/owner

Hearer sub-roles

- **Roles**
  - Addressee (spoken directly to)
  - Side participant (ratified)
  - Bystander (tolerated)
  - Eavesdropper (unknown)
- **Issues: who gets/has/does/is**
  - Signals from speaker
  - Obligations to speaker
  - Right to become speaker
  - Speaker intend to hear (or intends not to hear)
  - Message designed for
  - Speaker awareness
  - Attention of participants

Speaker -> Addressee signals

- **Vocatives & semantic indications**
- **Message tailored for understanding**
- **Body orientation**
- **Gaze**
- **Gesture**
- **Mirroring**

Addressee -> Speaker signals

- **Attention (ratification)**
  - Gaze
  - Posture/orientation
  - mirroring
- **Uptake**
  - Nods, head shakes
  - Facial expressions
  - Eyebrow flashes
- **Turn-taking**
  - Feedback
  - Hands in gesture space
  - gaze

Speaker ID

- **Two Party:**
  - If not me, then you
- **Multi-party:**
  - Audio
    - Acoustic features
    - Self ID
    - Style features/content
  - Multi-modal
    - Stereo localization
    - Visual identification (lips moving, gesturing)

Addressee Identification

- **Two-party:**
  - Non-speaker
- **Multi-party**
  - Speech/Text
    - Vocatives
    - Content
    - Context
  - Multimodal
    - Gaze
    - Orientation
    - gesture

MRE Multi-party (speech or text) Addressee Identification: Algorithm

1. **If utterance specifies addressee**
   - Vocative
   - not expecting short answer or clarification of person type

   ⇒ Addressee = specified addressee
2. **Else If current utterance speaker is same as previous utterance speaker**

   ⇒ Addressee = previous addressee
3. **Else If previous speaker≠ current speaker**

   ⇒ Addressee = previous speaker
4. **Else if (active) conversational participant in same conversation**

   ⇒ Addressee = participant
5. **Else ?**

Adding Orientation

1. **If utterance specifies addressee**
   - Vocative
   - not expecting short answer or clarification of person type

   ⇒ Addressee = specified addressee
2. **Else if speaker facing someone**

   ⇨ Addressee = faced participant
3. **Else If current utterance speaker is same as previous utterance speaker**

   ⇒ Addressee = previous addressee
4. **Else If previous speaker≠ current speaker**

   ⇒ Addressee = previous speaker
5. **Else if (active) conversational participant in same conversation**

   ⇒ Addressee = participant
6. **Else ?**

Participant Roles

- **Conversational Roles**
- **task roles**
  - authority, responsibility, participant, desire, guard
- **social roles**
  - Status: superior, subordinate, equal, incomparable
  - Closeness: friend, comrade, colleague, acquaintence,stranger, opponent, antagonist
- **activity roles**
  - e.g. courtroom: judge, bailiff, lawyer, witness

Change in Participant Status

- **Turn-taking**
  - Addressee -> speaker
    - Speaker selection
    - Self-selection
  - Other -> speaker
  - Speaker -> addressee (or other)
- **Addressee -> other**
  - Speaker addressee shift
  - Addressee attention shift
- **Other -> addressee**
  - Addressee-like behavior
    - Attention, grounding
  - Speaker inclusion

Activity-oriented talk

- **Main Activity -ratified speakers & addressees**
  - Offline (among speakers, not meant for ratified listeners)
- **Byplay - ratified addresses & side participants**
  - Borderplay (Brandt) - addressees & other ratified
- **Sideplay - unratified overhearers**
- **Crossplay - ratified & unratified**

Example Vhuman Inclusion behavior

Multi-threading

- **Two-Party**
  - Topic-shifts
- **Multi-party**
  - Multiple active threads
  - Separate conversations
  - Parallel conversations
    - Dependency
    - influence
  - Dynamic starting, ending, splitting, merging, entry, exit

Conversation/thread Identification

- **Two-party**
  - Single conversation
  - Topic coherence
- **Multi-party**
  - Channel/conversation relationship
  - Addressee/conversation relationship
  - Topic/conversation relationship

Turn-taking

- **Model:**
  - Cues (basic physical performances)
  - Signals (cluster of one or more cues indicating intent regarding turn)
  - acts (turn-taking results, given context of all participants actions)
- **Two-party**
  - Take-turn, hold-turn, release-turn
- **Multi-party**
  - Assign-turn, request-turn
  - Management across channels
  - Management across conversations

Initiative

- **Two-party**
  - System, user, mixed
- **Multi-party**
  - Asymmetric
  - Cross-initiative
    - Address different participant
    - Different participant interjects
  - Cross-conversation initiative

Addressee Obligations

- **Two-party**
  - Addressee has obligation to act
- **Multi-party**
  - Obligations from multi-addressee?
    - Indefinite obligation (group obligation)?
    - Distributed obligation to all?
    - No obligation (option)?

Grounding

- **Two-party**
  - existing models, e.g. Traum&Allen 92
  - Signals of understanding from addressee needed for grounding
- **Multi-party**
  - signals from whom? One participant? All?

Multi-party grounding model

- **Implemented:**
  - Multiparty conversation, single addressee
  - Components:
    - State
    - Initiator
    - Responder
    - Contents
- **Multi-addressee**
  - Any addressee acknowledgement grounds
  - Split into multiple single speaker-addressee units
- **Cross-grounding**

Evaluation

- **Two party**
  - Task success
  - Naturalness
  - Efficiency
  - Usability
- **Multi-party**
  - Individual or combined measures?
  - Total effort or real-time?

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