

ATTEND
**Analytical Tools for Evaluating
Negotiation Difficulty**

Alejandro Bugacov Murilo Coutinho

Peter Will

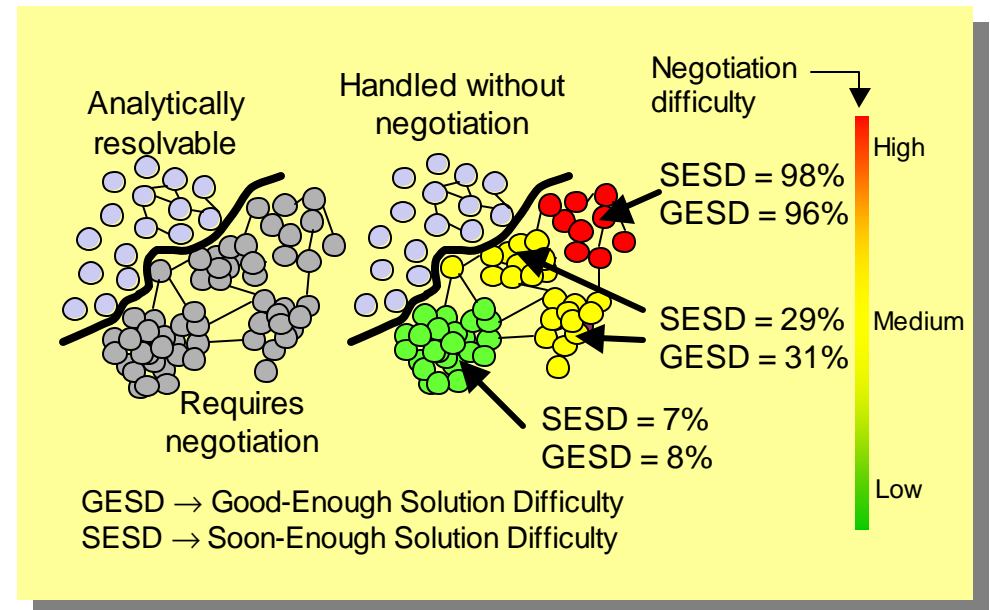
Robert Neches

USC Information Sciences Institute

May, 2000

Key Ideas: Difficulty Warnings that Allow Negotiation Systems to Adapt

- **Partition task space** into
 - Those that truly requires negotiation
 - Those that can be solved analytically
- **Identify groups** with different level of difficulty
- **Negotiation difficulty warnings** based on problem complexity
- **Techniques made available** to any negotiation system via a general API



Impact on Negotiations:

Adapt to Time & Quality

- Systems lack analytical methods to **estimate negotiation difficulty** and adapt their behavior accordingly:
 - Can negotiations find any solution in the time available?
→ **Convergence**
 - Can negotiations find solutions with the desired quality and time constraints? → **Closure**
 - Can external changes destabilize the system? → **Stability**

Relation of Techniques Under Consideration to Technical Goals

Identify tasks that truly require negotiations

Form groups with different difficulty level

Generate difficulty warnings by group

API

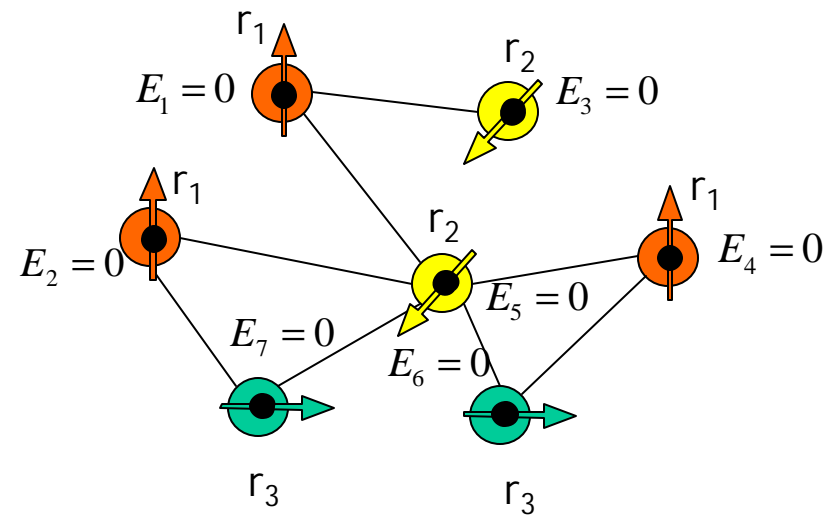
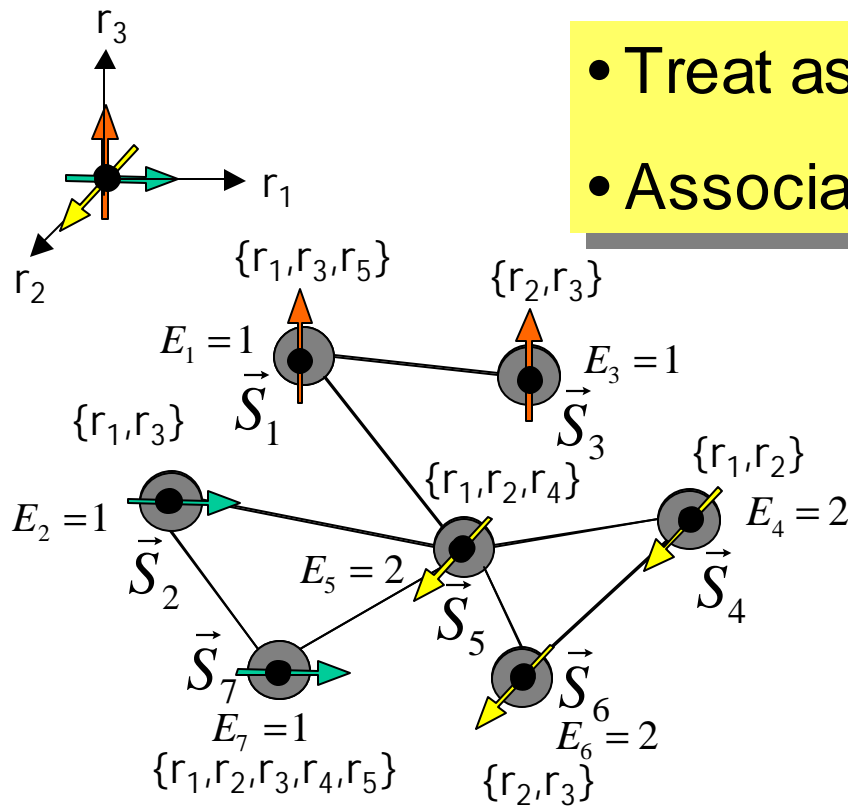
Graph
Coloring

Phase
Transition
Curves

Graph
Partitioning

Resolving Resource Conflicts: Graph-coloring

- Treat as a system of interacting magnets
- Associate colors with vector orientations

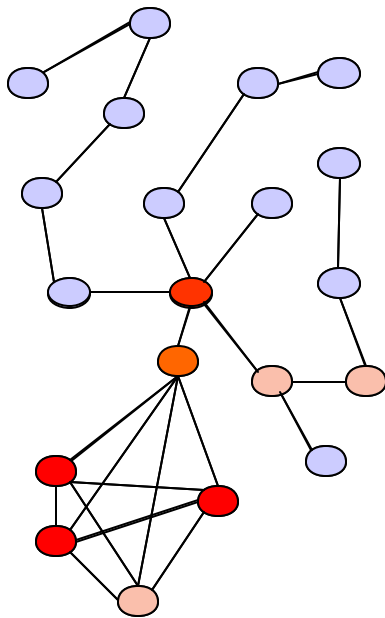


Solve → Minimize the Energy of the System

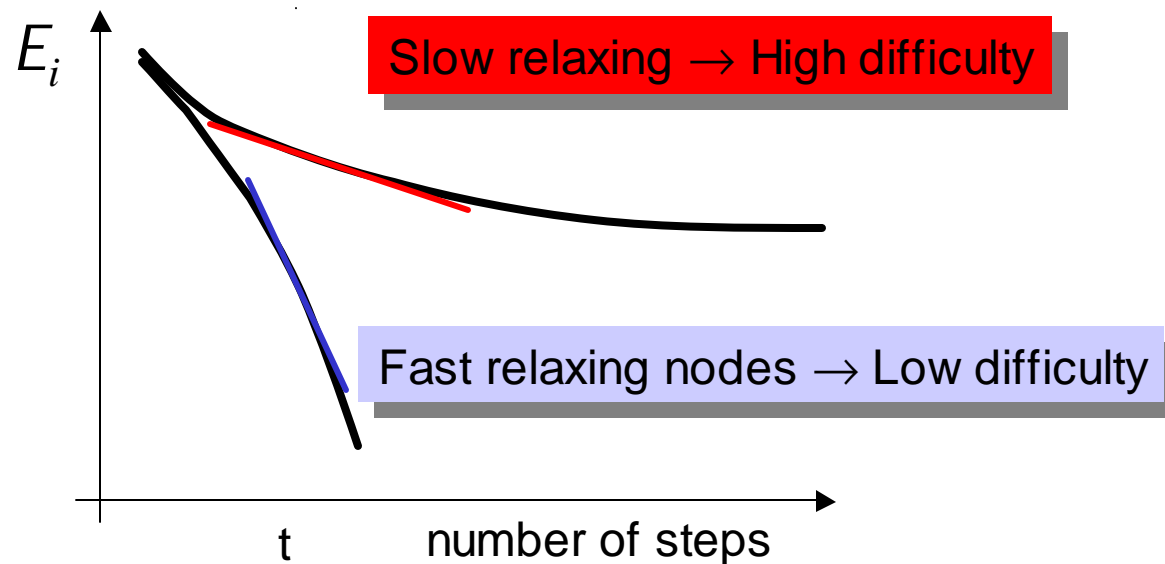
$$E = \frac{1}{2} \sum_{ij} w_{ij} \vec{S}_i \cdot \vec{S}_j$$

Statistical Mechanics Approach: Color-flipping Mechanism

$$E = \frac{1}{2} \sum_{ij} w_{ij} \vec{S}_i \cdot \vec{S}_j$$

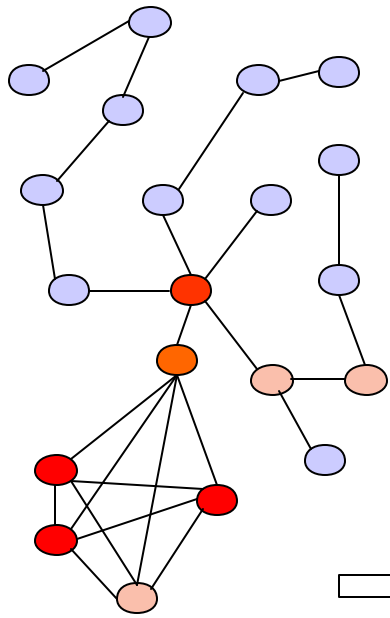


Track the energy relaxation with the number of color flips during minimization using a Metropolis-type algorithm



Algebraic Approach: Linear, Quadratic and Integer Programming

$$E = \frac{1}{2} \sum_{ij} w_{ij} \vec{S}_i \cdot \vec{S}_j \quad \Rightarrow \quad E = \frac{1}{2} [s^T \cdot A \cdot s - N]$$



- Minimization of E with binary constraints
- Conjugate gradient algorithm $\rightarrow A \cdot s = b$
 - Iteratively improve solutions
 - Linear scaling with number of nodes

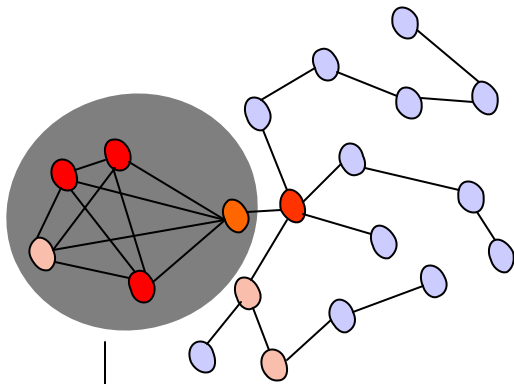
$$s^T = [1 \ 0 \ 0 \ 0 \ 0 \ 1 \ \dots \ \dots \ 0 \ 1 \ 0]$$

State Vector

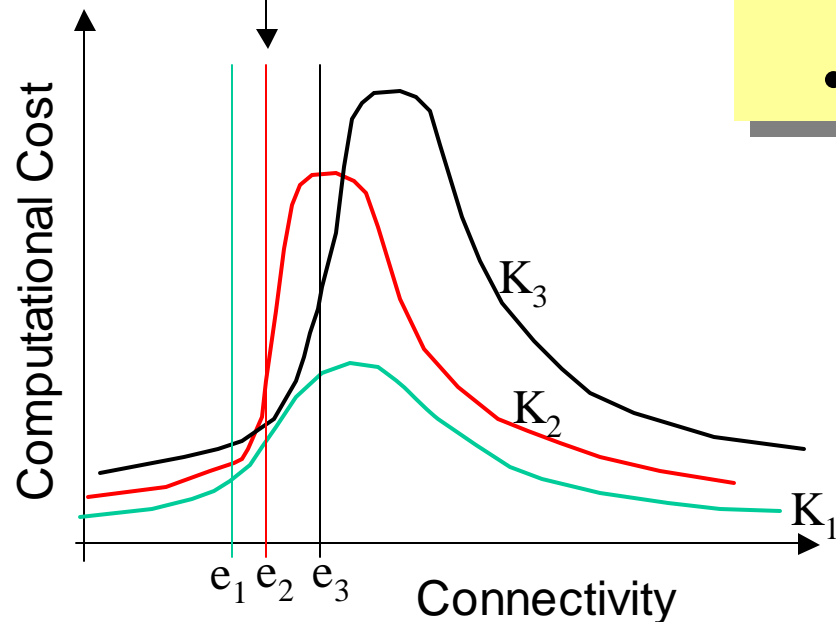
$$A = \begin{pmatrix} 1101010001 & 1010101001 & 1100000000 \\ 1111101000 & 0000111000 & 0000000000 \\ 0001110110 & 1011000011 & 1001101101 \\ 0000111001 & 1000100001 & 1010000000 \\ 1000000000 & 1111000000 & 1000011100 \\ 0001110110 & 1011000011 & 1001101101 \\ 0000111001 & 1000100001 & 1010000000 \\ 1101010001 & 1010101001 & 1100000000 \\ 1111101000 & 0000111000 & 0000000000 \\ 0001110110 & 1011000011 & 1001101101 \\ 0000111001 & 1000100001 & 1010000000 \\ 1000000000 & 1111000000 & 1000011100 \\ 0001110110 & 1011000011 & 1001101101 \\ 0000111001 & 1000100001 & 1010000000 \\ 0001110110 & 1011000011 & 1001101101 \\ 0000111001 & 1000100001 & 1010000000 \end{pmatrix}$$

Connectivity Matrix

Phase-Transitions: Problem Difficulty Characterization



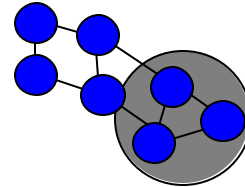
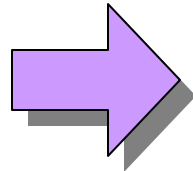
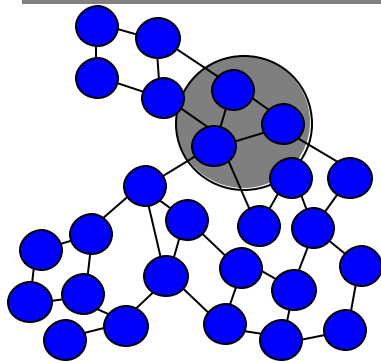
- Use transition curves and local value of the order parameter to:
 - Identify groups with different difficulty level
 - Generate difficulty warnings by groups



K_i = number of available colors per node

Graph Partitioning Techniques: Clique Separation

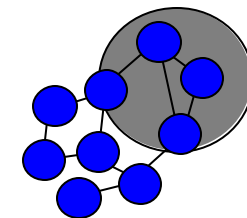
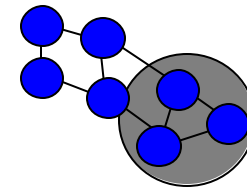
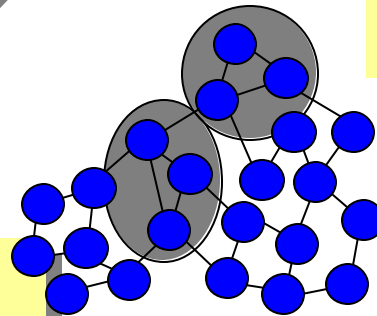
Set of Tasks with
high negotiation
difficulty



Task space subdivided
into regions of decreasing
negotiation difficulty

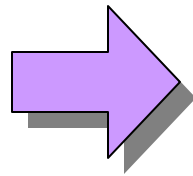
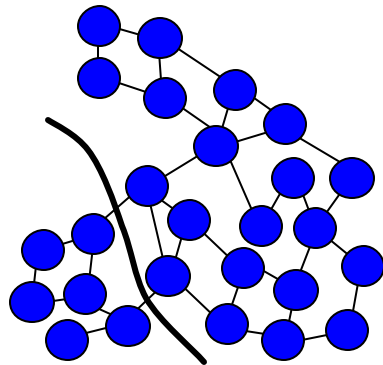
Identify clique that
separates task
into two region

Continue until no more
clique separators are found

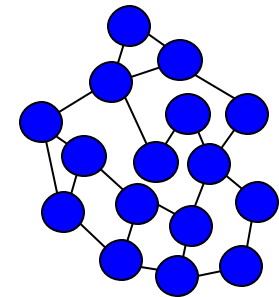
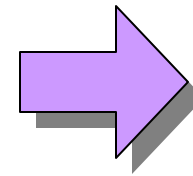
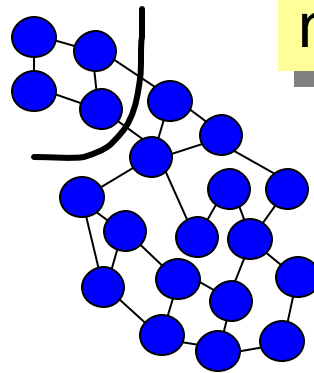


Graph Partitioning Techniques: Minimum Edge Cutting

Set of Tasks with high negotiation difficulty

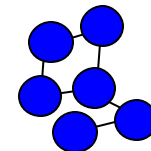


Task space subdivided into regions of decreasing negotiation difficulty



Dissect the graph into two groups using minimum edge line

Continue until negotiation difficulty in each subgroup decreases to an acceptable low level



Current Status: Activities in Progress

Performing a trade-off analysis
between alternative graph partition
and coloring techniques



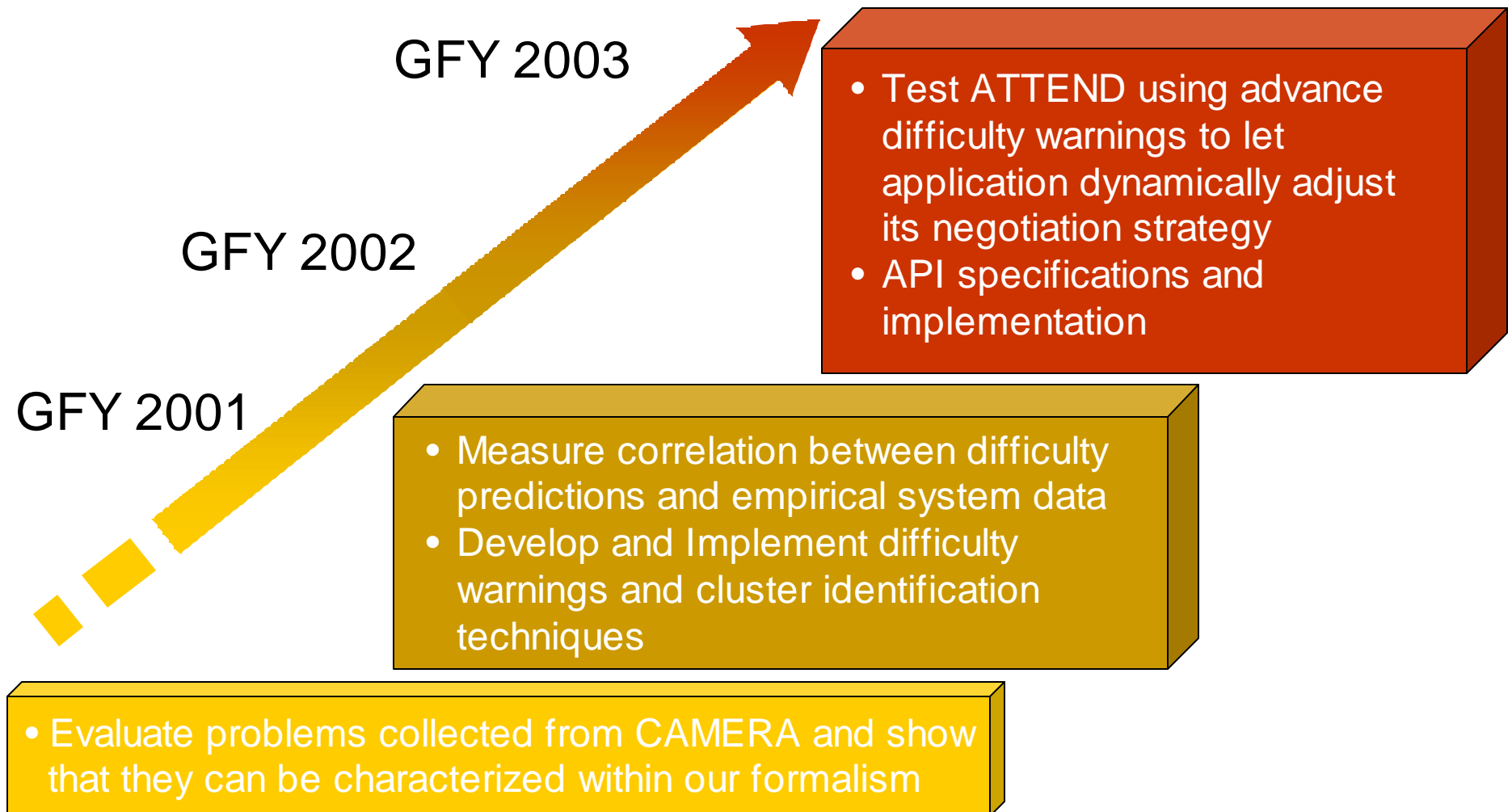
Developing detailed integration plan:

- CAMERA and its current application
- Possible other ANTs efforts

Refining incremental
implementation plan



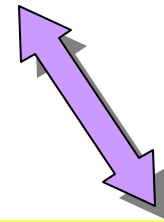
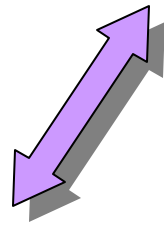
Progress Evaluation: Increasing Predictive Power, Provided More Quickly



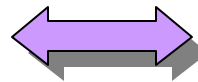
Summary:

ATTEND Will Deliver ...

Set of techniques to provide negotiation difficulty warnings that will enable systems to rapidly adapt to time & quality constraints



API to make the techniques available to people who want to use them



Demonstration of the effectiveness of the techniques through a tie to CAMERA