Identifying Critical Resources and Operations of the Adversaries from Incomplete Data

Georgiy Levchuk
Bruce Skarin
Krishna Pattipati

Presented at 2009 ICCRTS

Date: 06/17/2009

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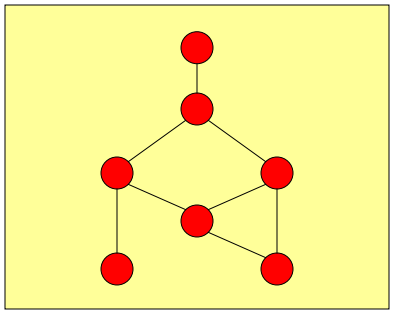
Agenda

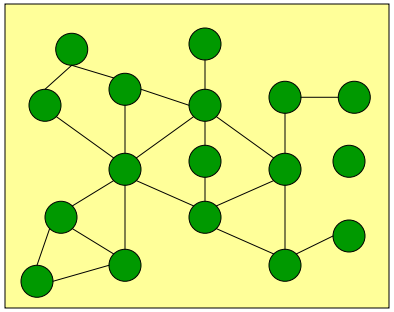
- Definitions
- Problem
- Approach
- Results

Definitions-1



- **RED**
  - adversaries, target of analysis

- **BLUE**
  - friendly forces, users of the tool, analysts



- **GREEN**
  - "normal" (local) population, not RED/BLUE

- **Resources**
  - people, materials, physical infrastructure, information, etc.

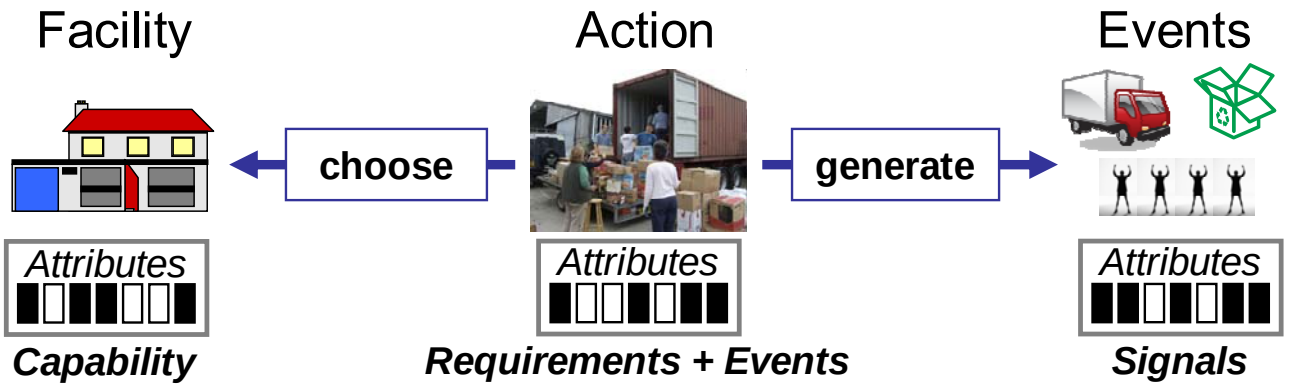
Definitions-2

- **Actors**
  - people, moving objects (e.g., cars), places
- **Actions**
  - performed by actors
- **Attributes**
  - quantitative description for actors (capabilities, preferences, objectives) and actions (requirements, outcomes)

Definitions-3:
Attributes & specification of the relations between observations, actors, and actions

Examples of attributes:

- **Choice/req-s attributes:** why would a facility be used to carry an activity
  - Example: "*assemble weapons in building with electricity supply and extra generator*"
- **Signal/event attributes:** what data might be observable if the activity is taking place
  - Example: "*weapons assembly activity would generate a spike in electricity use, which might be observed if electricity flow is monitored*"



Data: Choice Attributes | **Model: Choice & Signal Attributes** | **Data: Signal Attributes**

Definitions-4

- **Sensors / data sources**
  - HUMINT, SIGINT, IMINT, MASINT, OSINT, GeoINT
- **Observations**
  - quantitative and qualitative data obtained by sensors about actors and actions
- **Behaviors**
  - (patterns of) actions, either oriented by objective or not

Definitions-5: Behavior Types

- Single objects…

entering building

digging a hole

- Multiple objects…

meeting

playing

- Static objects…

gas station

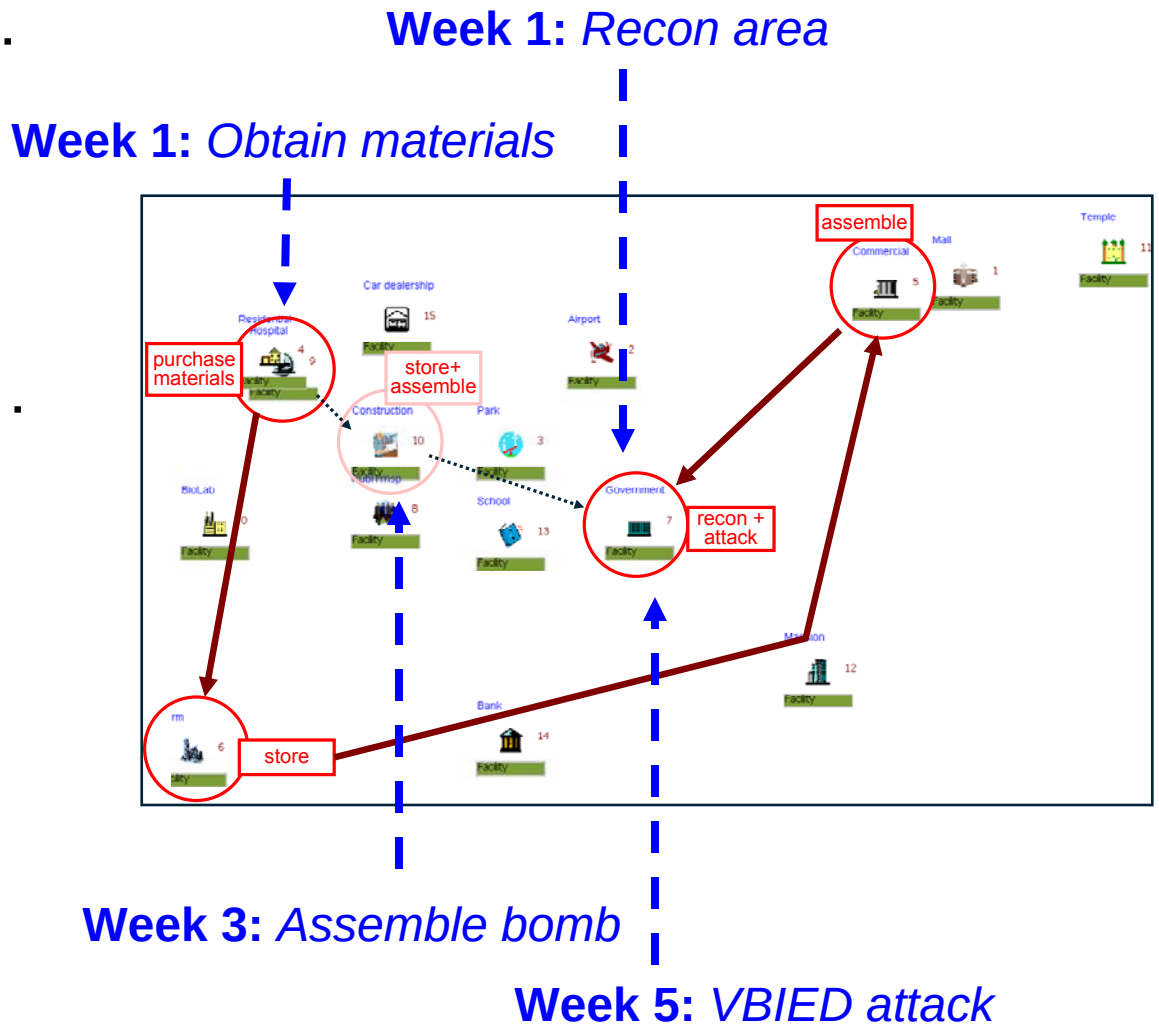
kindergarten

Definitions-6

- **Networks**
  - actors, their roles, and their relationships
- **Missions / scenarios**
  - plans composed of patterns of actions oriented by an objective
- **Behavior Signature**
  - network(s) + mission(s)

Definitions-7: Missions = Coordinated Behaviors

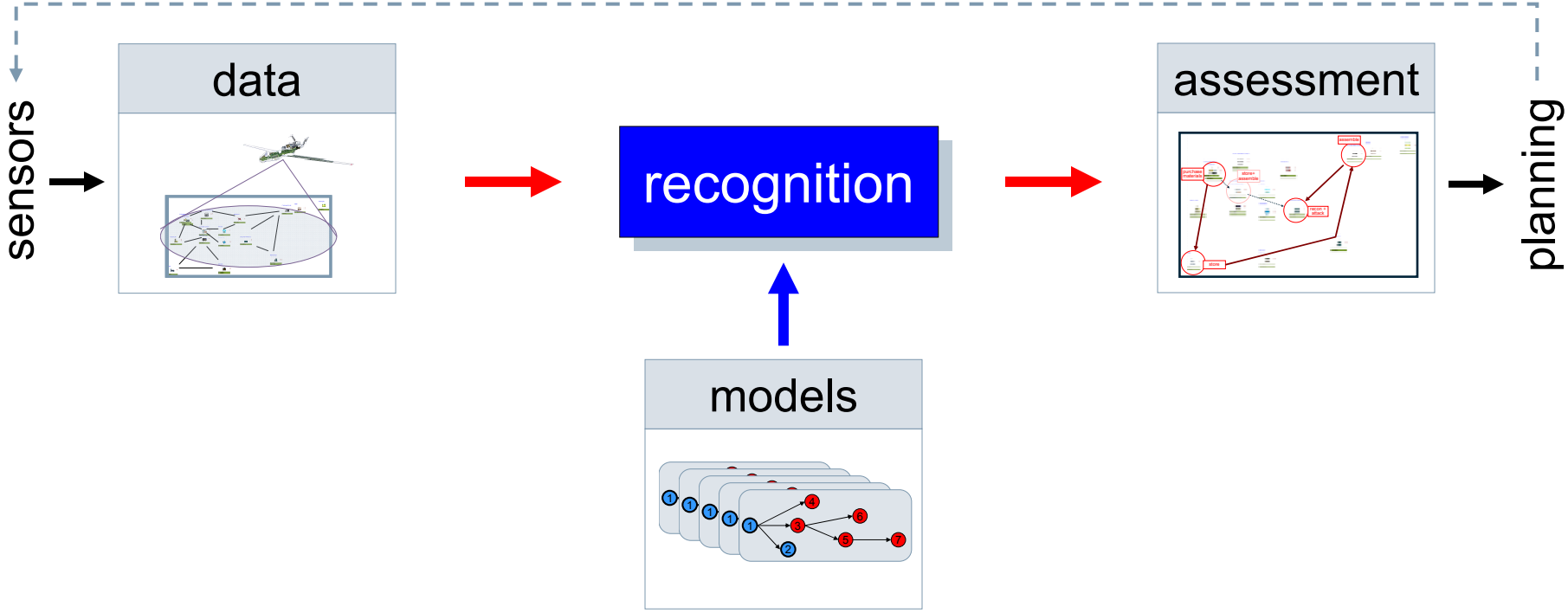
- Multiple places…
- Different actors…
- Different times…



Definitions-8

- **Data**
  - all observations
- **Models**
  - known patterns of behavior, missions, and network (sub)structures

The Problem



- Given **data** about urban terrain and knowledge of possible hostile **behaviors** identify true ***hostile activities*** **(what, where, when, & who)**

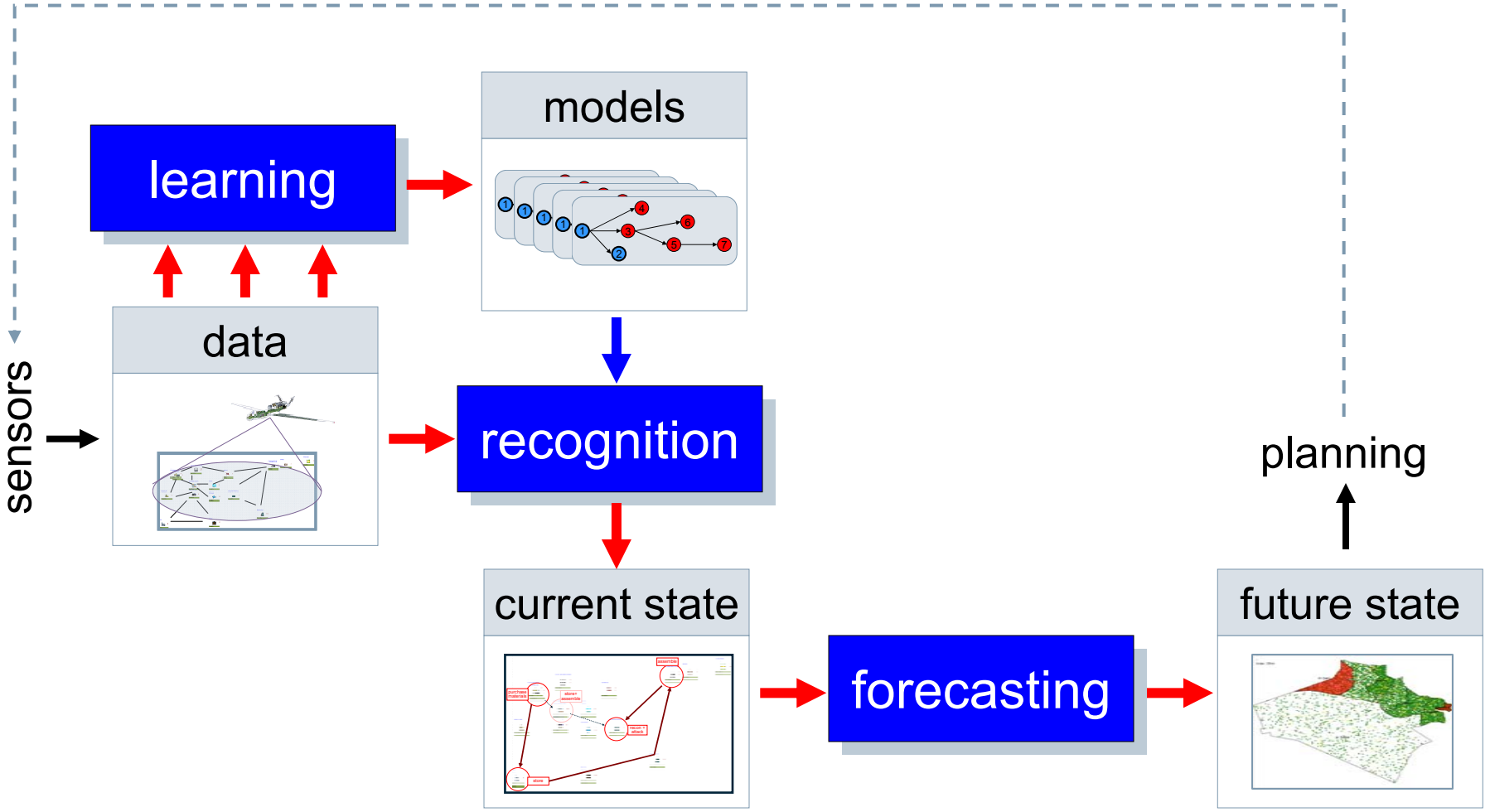
General Needs

- **Recognition/classification = what HAS happened**
  - given set of known behavior signatures and data about activities in the area of interest, identify what has actually been done and by whom (current state)

- **Forecasting = what WILL happen**
  - given current state (of networks and missions), identify what actions will be done in the future, where, and by whom (future state)

- **Learning = what MAY happen**
  - given sequences of behaviors, learn behavior signatures/patterns (possible states & dynamics)

The Problem: Expanded Schematic

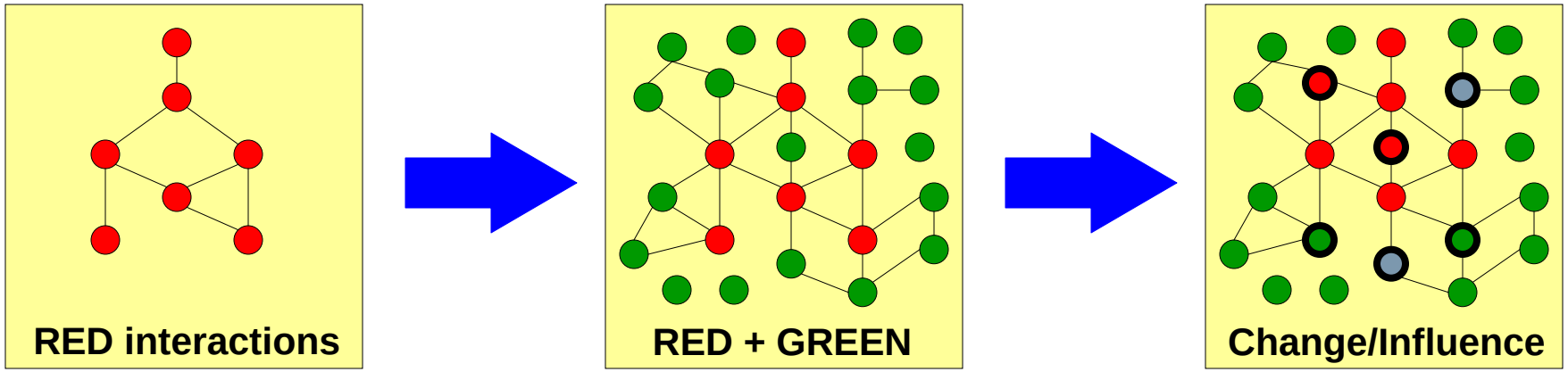


Addressed Need: Identification of Critical Resources

- Knowledge of what has happened or will happen is not enough for action
- Need to understand who will do what and when and where
- To act against specific actions or actors, need to know who/what is **CRITICAL**, and who/what is not
- Example:
  - ***Suicide bomber*** may not be critical because he/she can be replaced by many others, but ***weapons supplier***, or ***money provider***, or ***shelter/transport source*** may be critical

- Conclusion:
  - Criticality analysis requires assessing actor-action dependencies and diverse set of possible futures

One More Challenge usually Avoided by Researchers



- **Not only does**
  - RED signal is mixed with and confused by normal/GREEN events …
- **… but most importantly**
  - **RED** interacts with **GREEN** (socio-cultural environment), changing its actors and actions

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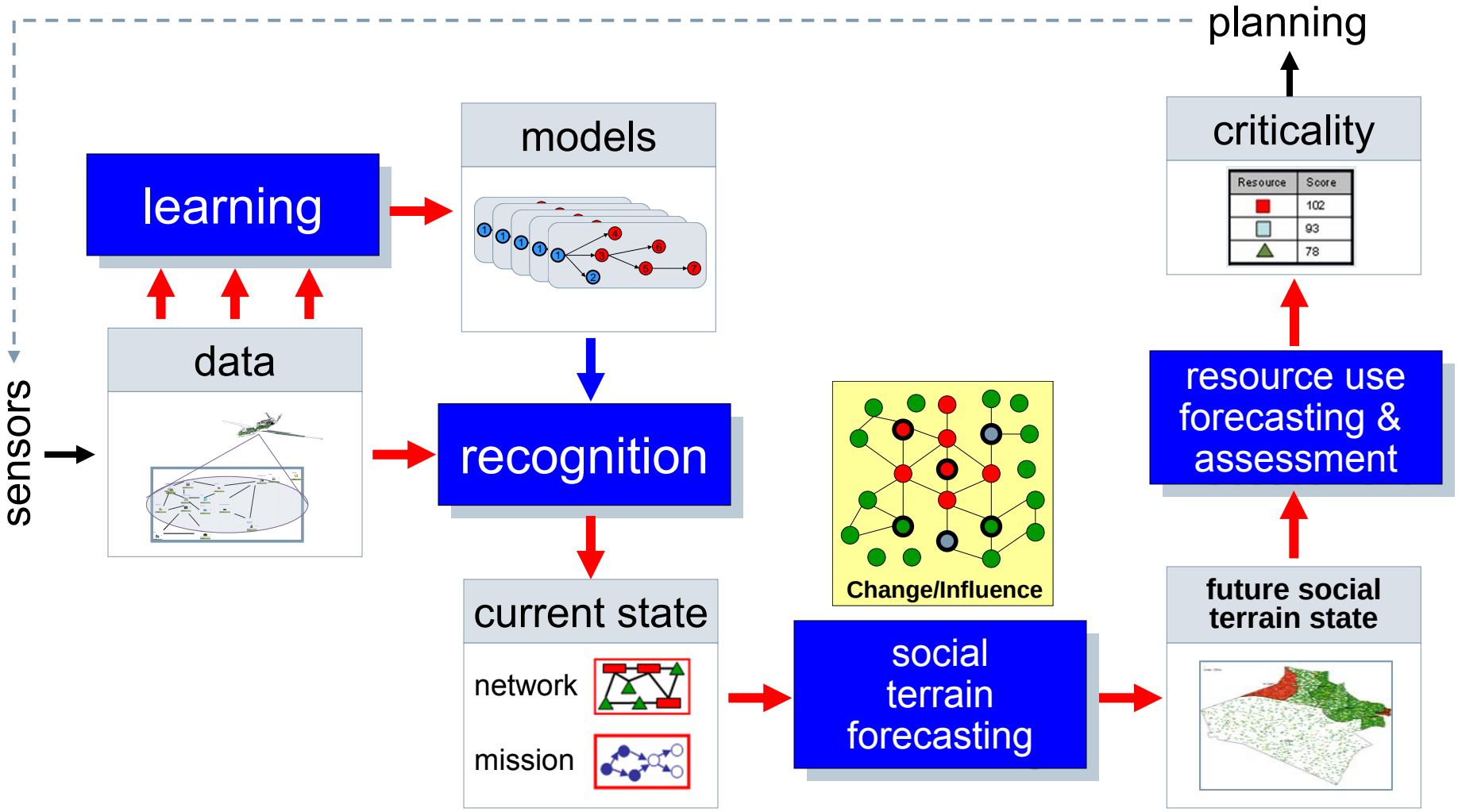
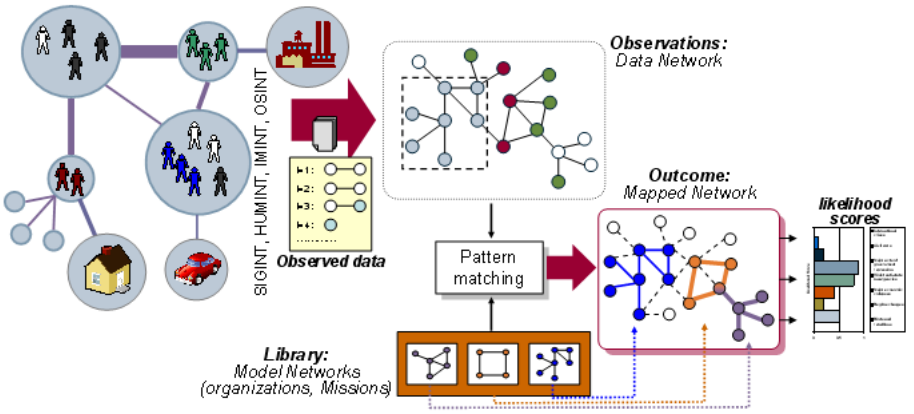
Our Approach: Advanced Schematic

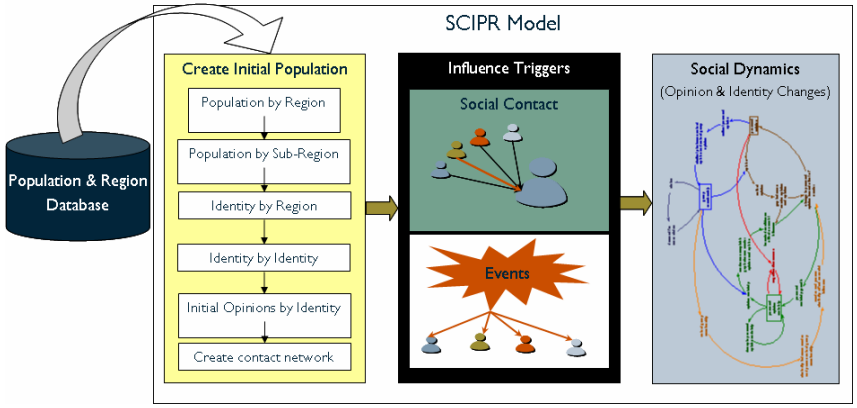


Component Technologies

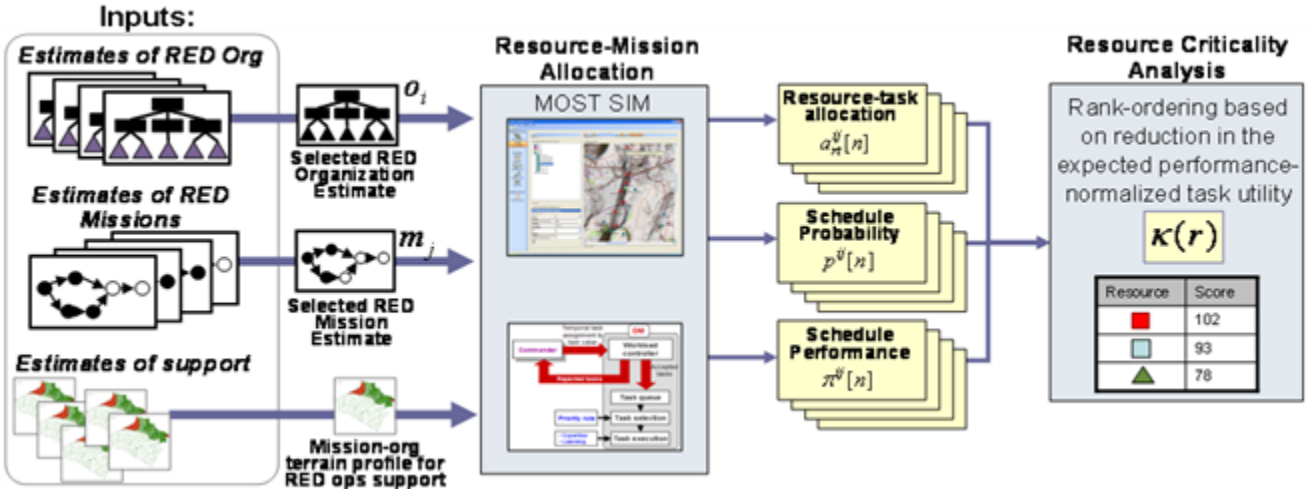
Behavior recognition: RED Network and Mission



Social terrain forecasting:
Support of RED in Environment



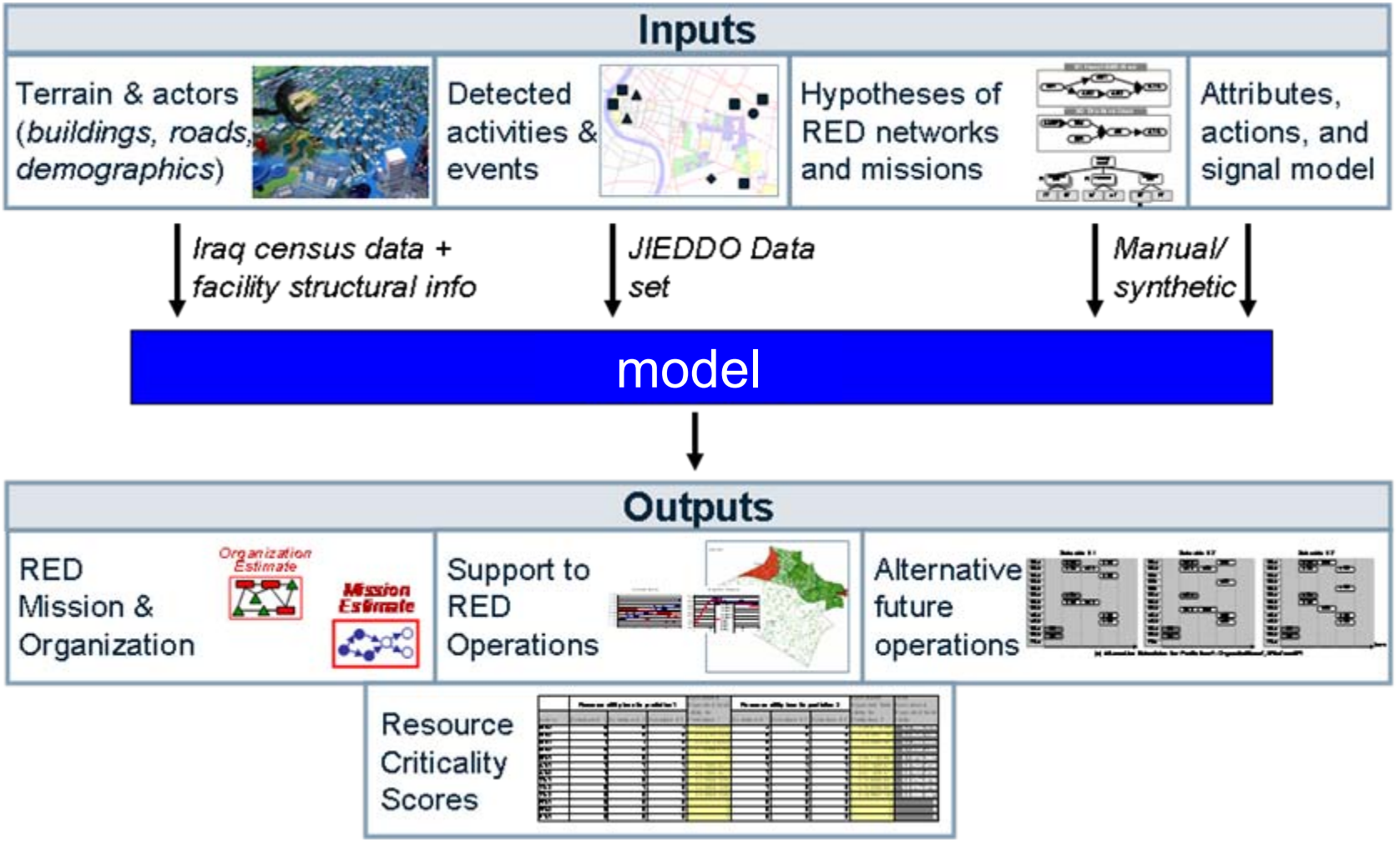
Resource utilization and criticality assessment:
Criticality of RED Resources and Operations



Summary of Accomplishments

- Used several **real-world data sets** supplemented by synthetic data with ground truth for evaluating our technology
- Achieved >70% accuracy in **identifying RED networks and missions** under very high noise levels
- Develop **forecasts of social terrain** indicating **changes in RED networks, resources,** and **support** for their operations
- Develop **forecasts of alternative future operations and involvement of RED actors**
- Develop **robust metrics of RED resource and operation criticality** derived directly from resource utilization profiles obtained by recognition and forecasting models

Analysis' Inputs and Outputs

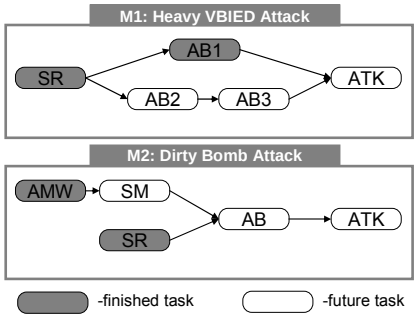


Assessing Criticality:
Develop Potential Actor-Action Execution Schedules for Unfinished Operations

Input: Predictions of RED Missions, Organizations, and Population Activity Support Opinions

Mission	Probability
M1: Heavy VBIED Attack	.7
M2: Dirty Bomb Attack	.3
M3: Hostage Taking	0
M4: Contaminate Water Supply	0
M5: Site Attack and Mining	0

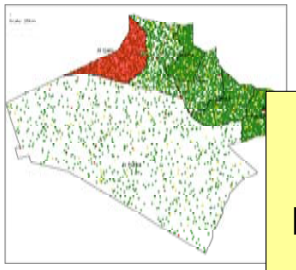
(a) Mission Predictions



(b) Estimates of Mission State

Organization	Probability
Alternative 1	0
Alternative 2	0
Alternative 3	0
Alternative 4	1

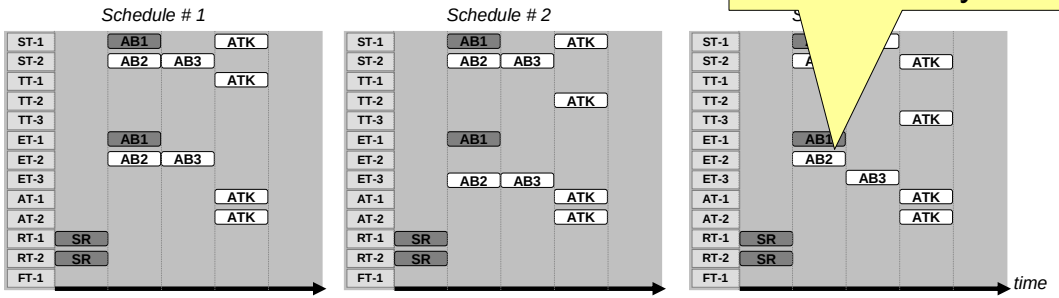
(c) Organization Predictions



(d) Social Terrain Profil

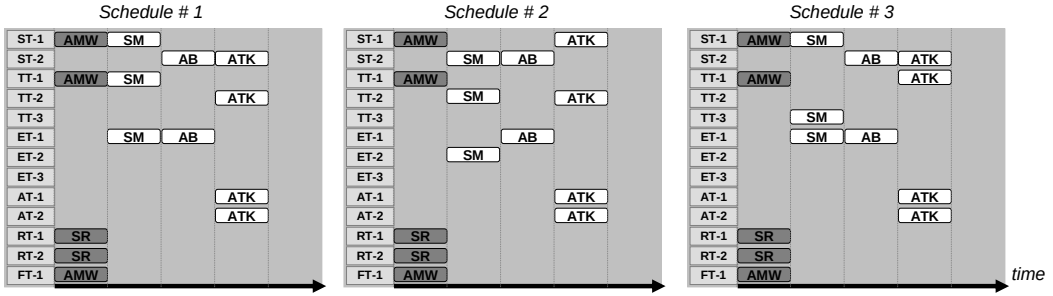
Actor **explosives specialist-2** is participating in activity **assembling bomb-2** on day 2

Resources use sim



(a) Alternative Schedules for Prediction 1: *Organization=4, Mission=M1*

Output: Simulated Actor-Action Schedules (*who does what when, where, and how*)



(b) Alternative Schedules for Prediction 2: *Organization=4, Mission=M2*

Criticality Analysis:
Score Criticality of RED Resources/Actors to their Mission's Success

Actors	Resource utility loss for prediction 1			Normalized Expected Task Utility for Prediction 1	Resource utility loss for prediction 2			Normalized Expected Task Utility for Prediction 2	Total Normalized Expected Task Utility
	Schedule # 1	Schedule # 2	Schedule # 3		Schedule # 1	Schedule # 2	Schedule # 3		
ST-2	6	6	1	0.333333333	3	6	3	0.285714286	0.319047619
ET-2	6	0	6	0.307692308	0	6	0	0.142857143	0.258241758
ST-1	1	1	6	0.205128205	6	1	6	0.30952381	0.236446886
ET-3	0	6	0	0.153846154	0	0	0	0	0.107692308
ET-1	0	0	0	0	6	3	6	0.357142857	0.107142857
AT-1	1	1	1	0.076923077	1	1	1	0.071428571	0.075274725
AT-2	1	1	1	0.076923077	1	1	1	0.071428571	0.075274725
TT-1	1	0	0	0.025641026	6	0	1	0.166666667	0.067948718
TT-2	0	1	0	0.025641026	1	6	0	0.166666667	0.067948718
TT-3	0	0	1	0.025641026	0	0	6	0.142857143	0.060805861
RT-1	0	0	0	0	0	0	0	0	0
RT-2	0	0	0	0	0	0	0	0	0
FT-1	0	0	0	0	0	0	0	0	0

Top 3 most critical RED actors

$$\kappa(r) = \sum_{ij} p_i^O \, p_j^M \sum_n p^{ij}[n] \frac{u_n^{ij}(r)}{\pi^{ij}[n]}$$

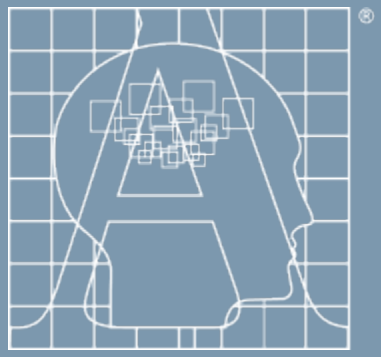
- Example: actor **Support Team-2** scores the highest
  - This result matches the fact that this actor participates in all forecasted alternative mission execution policies for RED and is involved in early stages of its operations
  - Its disruption will degrade RED's performance the most and thus would provide the highest benefit to BLUE
- During our analysis, we obtained the criticality scores of RED resources (members of hostile organization and areas where RED may perform their actions) that have been aligned well with the actual involvement of those resources in future hostile activities

Conclusions

Planning designs actions

- **Actions** are designed against specific actors or actions
  - **Specific actors or actions** can be determined analyzing their criticality to overall RED objectives within corresponding behavior models
    - **RED** is hidden in the GREEN environment and interacts with it
    - **RED** changes its behavior over time

- Therefore, to be successful, planning requires integrated *recognition*, *learning*, and *forecasting* tools
  - Various tools have been under development in several programs sponsored by DoD, and we have recently started to integrate them providing more accurate products for a variety of data sets



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