ONE BRICK AT A TIME
LAYING THE FOUNDATION FOR SUCCESS

A Feasibility Study for the COMP 2910 Spring 2008 Project by Team Hadaga

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SUMMARY

Team Hadaga has initiated the planning phase of our Spring 2008 COMP 2910 project. We are excited to provide you with detailed information about our initial planning strategies as well as the team communication and conduct guidelines that we have established.

Team Hadaga's primary goal is to construct a robot using the Lego MindStorm NXT building system, program it with Java (Lejos), and win the tournament. Secondary goals include earning excellent marks and building upon project planning, analysis and implementation strategies learned in COMP 2730 Systems Analysis and Design. Tertiary goals include mastering a process-oriented point of view that emphasizes teamwork and fun, and learning how to deploy a working system with a new technology. We also hope to use concepts we have learned this year, such as cohesion, coupling, modularization (of code and robot parts) and recursion.

Team Hadaga believes identifying strong communication guidelines is a winning strategy for successful teamwork. We have chosen to inculcate an open and respectful group dynamic when communicating in person, by email and in our new private online forum. We will achieve consensus through discussion and group decision-making. Our rules of conduct require mandatory attendance and rotating responsibilities at all meetings. Team Hadaga will use a task-based iterative approach to complete the project, and consult with our Mentor on a biweekly basis for guidance and advice.

INITIAL STRATEGIES

At this nascent stage of the project our initial discovery and assessment of the problem remains, of course, incomplete. In order to create a realistic and achievable strategy, we still require:

- knowledge about the Java (Lejos) NXT API
- details about what assistance we may expect from our Mentor, Albert Wei
- considerable systematic and hands-on prototyping with the Lego NXT system to determine its capabilities and limitations.

Thus far, we have implemented the following strategies toward successfully completing this project:

1. We have purchased two (2) Lego MindStorm NXT kits in order to gain a realistic amount of practice designing, constructing and deconstructing prototypes.
2. We have acquired these four (4) books:
    a. Extreme Nxt: Extending The Lego Mindstorms Nxt To The Next Level
    b. Unofficial Lego Mindstorms NXT Inventor's Guide
    c. LEGO MINDSTORMS NXT Hacker's Guide
    d. Maximum Lego NXT: Building Robots with Java Brains.
3. We spent a significant amount of time in brainstorming and whiteboard meetings on Monday 21 April, Tuesday 22 April and Wednesday 23 April analyzing mission requirements and parsing each mission in pseudocode.
4. We have begun to consider ways to nest/interweave missions in order to complete them concurrently.
5. We have identified online sources for extant strategies relevant to each table:
    a. YouTube has a number of videos which we have begun to watch and analyze for mission order and concurrency.
    b. Unofficial strategy websites offer advice from First Lego League participants.
6. In addition to writing mission code, we will also write some contingency code and robot attachments to deal quickly and effectively with problems should they occur (for example, a program that sends the robot out to collect balls from a specific area in the NW quadrant that have been pushed into our court).

BUILDING TRUST WITH CONSTRUCTIVE COMMUNICATION

From a project management and teamwork standpoint, we have identified three strategies for sharing ideas in constructive and positive ways:

1. in regular and formal daily meetings where decisions will be made through discussion and consensus
2. in email that is helpful, friendly and positive
3. in an online forum that also serves as a repository for all shared team documents.

FOSTERING EFFICIENCY AND EFFECTIVENESS WITH CLEAR BOUNDARIES

Team Hadaga has also identified rules of conduct that will provide us with boundaries for successful communication and team participation:

1. <u>MAKING ALL MEETINGS MANDATORY</u>
   We believe that punctual attendance at all meetings is necessary so that all five members of Team Hadaga may participate in all decision-making steps. In the event that

absenteeism becomes an issue, we have established a three-step corrective method that profits from your experience with teamwork:

1. Each team member may provide written advance notice that he must miss one meeting.
2. Each team member will receive a written warning if a second meeting is missed—we will provide you with a copy.
3. Each team member who fails to attend a third meeting will meet with you and the team to establish a consequence for the absenteeism.

2. <u>SETTING CLEAR STANDARDS FOR SUCCESS</u>
   Team Hadaga looks beyond the lowest common denominator and believes in bringing our team members to a higher level. Our measures for success are a final mark of 90% or greater and a positive and memorable team experience. We will achieve this goal in part by:

   1. establishing a work structure, or schedule, that uses an iterative approach to project development
   2. giving each team member the opportunity to express his opinions to an attentive and respectful audience at every meeting and during informal discussion
   3. agreeing that team members who consistently submit work that does not meet our collective standard of quality will meet with you and Team Hadaga to determine an appropriate academic penalty or recompense.

3. <u>ASSIGNING TASKS IN A FAIR AND CONSISTENT WAY</u>
   From rotating duties at each meeting to dividing work fairly based on each team member's strengths, Team Hadaga will ask its members to work hard, to work smart and to work together.

RISKS

A successful strategy is predicated on the thorough discovery of a problem's requirements. We have invested considerable time this week analyzing the rules and missions iterated in the course documentation, but we are not yet finished. At this early stage, there are still several unknowns which may/may not prove to be impediments:

1. Will our Mentor, who is a C instructor, be able to provide us with meaningful assistance in a Java environment?

2. Will we be able to use the Lego lab in a constructive and meaningful way to develop and prototype ideas without hindrance or interference?
3. Which specific SDLC should we choose that will best fit our learning curve and experience level?
4. Will our ideas translate into successful results?
5. Will we focus on one field or both fields?

It is unrealistic to know the answers to all these questions when our discovery is incomplete. Our team has begun rotating the MindStorm sets—taking the sets home and constructing and deconstructing the projects included with the kit will provide us with a good foundation for accumulating design and construction expertise.

ASSUMPTIONS

Team Hadaga has made the following assumptions:

1. Cheating will not be allowed.
2. Mentors will provide an equitable and helpful amount of assistance to each team.
3. Sufficient instruction and time will be given to master (or at least become comfortable) with the Java (Lejos) API.
4. The materials we need to complete our robot will be available.
5. Sufficient quality instruction and time will be provided so that we can properly model and practice a SDLC.

MISSION APPROACHES

Team Hadaga is pleased to provide you with the following preliminary brainstorming analysis of each mission listed in the documents in the "The Project" section of the COMP 2910 WebCT site.

NANO FIELD

Mission 1:	INDIVIDUAL ATOM MANIPULATION
Objective:	Remove at least 1 white atom from the blue surface without moving any red atoms, and return the white atom(s) to the base.
Approach 1:	We will build a robot that will travel to the model, extend 2 rods, and spread the rods to knock the correct atoms off the platform. The rods will be positioned high enough not to interfere with the red atoms.
Approach 2:	Same as approach 1, but we will collect the atoms in 'sandboxes' that have been attached to the robot.
Approach 3:	Same as approach 2, but we will add an attachment to the front of the robot to keep the base from wobbling. The attachment will also prevent the red atoms from being pushed off the platform.

Requirements: We will need to create a robot that:

1. is mobile
2. can extend and spread arms to knock off the correct atoms
3. has a sandbox attachment to catch the molecules
4. has a front attachment to prevent the platform from wobbling.

Reasoning: This approach is simple and straightforward. It may give us access to all of the attenuated atoms, and prevent the red atoms from falling on the ground, because the table will not be able to wobble and the red atoms will be trapped on the table.

Mission 2: SMELL

Objective: Push molecules from pizza field location to nose field location.

Approach 1: We will build a robot that will travel to the model and plough the molecules to the correct location.

Approach 2: We will build a robot that will travel to the model and drag the molecules to the correct location.

Requirements: We will need to create a robot that:

1. is mobile
2. has a plough or "collector" hoop that can be lowered to encompass and drag the molecules.

Reasoning: This approach is simple and straightforward, fast and easy. It will not require a motor and we will be able to use the same plough for other missions.

Mission 3: NANOTUBE STRENGTH

Objective: Push the truck into the elevator and activate the lift mechanism.

Approach 1: We will build a robot that will travel to the model and push the truck onto the elevator, reverse, lower a plough, and push the mechanism.

Approach 2: We will build a robot that will travel to the model and push the truck onto the elevator, and continue pushing the elevator mechanism inwards with a staggered (two-tier) plough.

Requirements: We will need to create a robot that:

1. is mobile
2. that has a simple plough (approach 1) or a staggered or two-tier plough (approach 2).

Reasoning: Sometimes simple is best. This solution doesn't use any additional parts and no motors are required.

Mission 4: STAIN RESISTANT FABRIC

Objective: Deliver a dirt trap to its location mark and completely dump the tester's dirt dumper, trying to get all the dirt into the dirt trap.

Approach 1: We will build a robot that will travel to, and push a dirt trap in front of the model.

Approach 2: We will build a robot that will travel to the model, push a dirt trap in front of the model, move around behind the model and bump (ram) the mechanism to dump the dirt dumper.

Approach 3: We will build a robot that will travel to the model, push a dirt trap in front of the model, lower a girdle over the model, and reverses several times to force the dirt particles to be released from the tray.

Requirements: We will need to create a robot that:

1. is mobile
2. can extend a girdle to depress the joint that causes the first tray to flip.

Reasoning: This approach is simple, fast and straightforward. It will maximize our chance for emptying the tray of all of its dirt. This approach is also much faster than driving around to the back of the trap, but we will have to use a motor to accomplish it.

Mission 5: ATOMIC FORCE MICROSCOPY

Objective: Free the probe's (magnetic) nanotip and ensure that it does not reconnect during the match.

Approach 1: We will build a robot that will travel to the model, extend an arm and lift the probe to separate the nanotip.

Approach 2: We will build a robot that will travel to the model, extend 2 vertically aligned arms between the probe and its base, and spreads both arms to separate the nanotip.

Approach 3: We will build a robot that will travel to the model and use an arm to push the magnet, separating the nanotip.

Requirements: We will need to create a robot that:

1. is mobile
2. can extend a Lego arm powered by a motor at the correct height to dislodge the tip.

Reasoning: This approach is simple and straightforward. It will maximize the robot's ability to dislodge the magnets by sliding one from the other, rather than just attempting to pull them apart.

Mission 6: SMART MEDICINE

Objective: Transport a buckyball from base to the red/yellow channel in the arm model.

Approach 1: We will build a robot that will travel to the model and drop the buckyball into the narrow channel.

Approach 2: We will build a robot that will travel to the model with the buckyball, and uses a "funnel bumper" to guide itself into place before releasing the ball.

Requirements: We will need to create a robot that:

1. is mobile
2. has a guiding funnel at the front end shaped like a corral, to assist the robot in approaching the model longitudinally
3. can drop the Buckyball into the channel.

Reasoning: This approach continues our investment in simple, effective solutions that are fast and foolproof. It will ensure the robot is aligned with the arm channel before dropping the ball. Variations in the robots path will have a minimal affect on the outcome of the mission

Mission 7: SELF ASSEMBLY

Objective: Travel to the model and cause the angled blue nanotubes to align horizontally end to end.

Approach 1: We will build a robot that will travel to the model, and bump the model to cause the tubes to align.

Approach 2: We will build a robot that will travel to the model, and bump the activation mechanism.

Requirements: We will need to create a robot that:

1. is mobile
2. can jostle the model with the correct amount of force.

Reasoning: It has been determined that extending a special arm to depress the lever is unnecessary—we need only smack the model with the correct velocity (speed and direction) to cause a transfer of momentum and energy.

Mission 8: SPACE ELEVATOR

Objective: Travel to the model and activate the elevator. We may also interfere with the other team by locking their elevator.

Approach 1: We will build a robot that will travel to the model, and activate the mechanism with pressure from a suitably-shaped front bumper.

Approach 2: We will build a robot that will travel to the model, release our elevator, move to the other elevator, and lock said elevator.

Approach 3: We will build a robot that will travel to the model, extend 2 arms and rotates to release our elevator and lock their elevator.

Approach 4: We will build a robot that will travel past the model, using a 2-tiered ram to release our elevator and knock the BALLS into the opposing court in the same sweep.

Requirements: We will need to create a robot that:

1. is mobile
2. can trace an arc while moving in order to activate the elevator and knock the BALLS into the opponents' court.

Reasoning: This is our first attempt to interleave/combine multiple missions on a single trip. We think there is a facility to doing these two missions at the same time.

Mission 9: MOLECULAR MOTOR

Objective: Deliver an ATP molecule into the motor, causing the motor to spin. We will have to engage the gear that causes the motor to spin.

Approach 1: We will build a robot that will travel to the model and drop the molecule in the appropriate spot.

Approach 2: We will build a robot that will travel to the model, engage the gear, and drop the molecule.

Approach 3: We will build a robot that will travel to the model, extend encapsulating arms to encircle the model, use a contact trigger on the front of the robot to set off an elasticized arm which will engage the gear, and then drop the molecule.

Requirements: We will need to create a robot that:

1. is mobile
2. has a contact sensitive trigger on the front bumper which activates an elasticized arm to engage the gear
3. can drop the molecule.

Reasoning: This is our first brainstorm that makes use of kinetic energy that is stored in an elastic. If this works during the prototype phase we will enjoy trying to incorporate more elastics in other missions.

Mission 10: BALLS

Objective: Knock 8 balls into our opponents' field.

Approach 1: We will build a robot that will scrape (move alongside) the wall with an elevated plough to knock four of the balls into the opposing field.

Approach 2: We will build a robot that will scrape (move alongside) the wall with an angled and elevated plough to push four of the balls into the opposing field.

Approach 3: We will build a SUPER FAST ROBOT that will plough four of the balls into the opposing field, travel in an arc around the elevators, and plough the remaining balls into our opponents' field.

Requirements: We will need to create a robot that:

1. is mobile and fast
2. has an elevated snowplough
3. can be programmed on site to plough 4 or 8 balls.

Reasoning: Although we recognize that getting all eight balls into the court will be a challenge, it is to our advantage to do so because a) there are 100 points available, and b) if we don't do it quickly, the other team will.

POWER FIELD

Mission 1: ROOF SOLAR PANEL
Objective: Carry a solar panel from base and place it on the roof of the house.
Approach 1: We will build a robot that will travel to the model and lowers the solar panel onto the house.
Approach 2: We will build a robot that will travel to the model holding the solar panel on a platform that rotates about the horizontal plane. When it bumps into the house with the required amount of force, the platform will spin the solar panel into the appropriate location on the house.
Approach 3: We will build a robot that will travel to the model with the solar panel in pincers and drop it onto the house.
Requirements: We will need to create a robot that:

1. is mobile
2. can grasp and carry the solar panel
3. can drop the solar panel into place.

Reasoning: This approach is simple and straightforward. We simply need to determine which approach works best in practice. It may be that pincers will allow the robot to drop the solar panel into exactly the right place with much better odds for success, worth the cost of using a motor.

Mission 2: PERSONAL VEHICLE CHOICE
Objective: Push the hydrogen car to the white property or all-black driveway by the house, and move the truck (with a single oil barrel) to the farm via base.
Approach 1: We will build a robot that will travel to the house dragging the car, with a contact-sensitive mechanism on the front bumper to release it. The robot will collect the truck, release the car in the parking spot, and return to base with the truck. We will remove all but 1 barrel and the robot will push the truck from base to the farm.
Approach 2: We will build a robot that will travel to the model, use a hook to tow the truck back to base, remove two of the three barrels leaving 1 red barrel in the truck, plough the truck to the farm, return to base, and push the car to the parking spot.
Requirements: We will need to create a robot that:

1. is mobile
2. can lower a hook and drag the truck
3. can push the car into place.

Reasoning: We have not yet completed our discovery for this mission and expect several eureka moments to evolve this mission.

Mission 3: HYDRO-DAM

Objective: Bring a dam from base to the field so that it is touching both banks of any river section east of base.

Approach 1: We will build a robot that will plough the hydro dam to the edge of the playing field.

Approach 2: We will build a robot that will carry the hydro damn to the edge of the playing field and drop it into place.

Requirements: We will need to create a robot that:

1. is mobile
2. can carry and lower the dam

Reasoning: We will be placing the dam as close to the border as possible in order to minimize the possibility that it will interfere with the field or flood communities. Placing it on the border may also have an effect on any BALLS being knocked into our field.

Mission 4: WIND TURBINES

Objective: Bring two wind turbines from base to the field so that they are upright and touching any white area not directly outside base.

Approach 1: We will build a robot that will plough them into white space.

Approach 2: We will build a robot that will plough them into space in conjunction with GRID CONNECTION.

Approach 3: We will build a customized plough that we will use in conjunction with the GRID CONNECTION.

Requirements: We will need to create a robot that:

1. is mobile
2. can traverse the field while pushing the turbines without tipping them.

Reasoning: By achieving this mission in tandem with the GRID CONNCTION mission we save time.

Mission 5: GRID CONNECTION

Objective: Bring the power lines from base to the field so that they are upright and touching the white of the Power Plant's property and the white of the surrounding communities.

Approach 1: We will build a robot that will plough the grid into place so it is touching the power plant and a single community.

Approach 2: We will build a robot that will use a custom plough to move both the grid and WIND TURBINES into position.

Requirements: We will need to create a robot that:

1. is mobile
2. can traverse the field while pushing the grid connection (and WIND TURBINES) without tipping them.

Reasoning: By achieving this mission in tandem with the WIND TURBINES mission we save time.

Mission 6: SOLAR-POWERED SATELLITE
Objective: Lower each of two satellites' panels.
Approach 1: We will build a robot that will bump one of the satellites and use the kinetic energy transfer to activate the panel.
Approach 2: We will build a robot that will use an angled plough to bump both satellites' activation levers while traversing across the field.
Requirements: We will need to create a robot that:

1. is mobile
2. has an angled plough
3. can traverse the field quickly and accurately.

Reasoning: This mission will be about speed and surprise in order to capitalize on the available bonus points.

Mission 7: WAVE TURBINE
Objective: Transport a team-designed wave turbine from base to the ocean directly west of the sandy beach.
Approach 1: We will catapult the turbine into place from base.
Approach 2: We will use a Lego person as a turbine and plough him/her into place.
Approach 3: We will use the robot as the turbine and end the match with it in place.
Requirements: We will need to create a robot that:

1. is mobile
2. has independently moveable parts
3. can end the mission in the ocean.

Reasoning: This mission will be creativity and finesse.

Mission 8: COAL MINING
Objective: Cause the loaded rail car to roll down the tracks and then transport it to base so we can prepare the coal for other missions.
Approach 1: We will build a robot that will lower an arm to release the lever, and then pick up and carry the cart by hand to base.
Approach 2: We will build a robot that will lower an arm to release the lever and carry the cart to base after it has touched the stoppers at the end.
Requirements: We will need to create a robot that:

1. is mobile
2. can trigger the level
3. can pick up and carry the coal cart to base.

Reasoning: We`re still not sure about the point value versus design profitability. We think it would be easier and faster to carry the coal cart to base by hand in order to ensure that we can use the coal for the POWER PLANT SUPPLY mission.

Mission 9: OIL DRILLING
Objective: Move all the barrels off the oil platform and transport them to the reserve in base.
Approach 1: We will build a robot that will travel to the model with a container, press the lever to knock the barrels into the container, leave the container.
Approach 2: We will use a ramp with a guard rail attached to the robot. The end of the ramp will be blocked to prevent the barrels from rolling out onto the field. The robot will carry them back with an arm of some sort.
Approach 3: We will build a robot that will travel to the model with a container, press the lever to knock the barrels into the container, and return with the container to base.
Requirements: We will need to create a robot that:

1. is mobile
2. can accurately position a container (perhaps attached) under the oil barrel slot
3. can return to base.

Reasoning: We wish to bring the oil barrels back to base—they are easy points.

Mission 10: CORN HARVEST
Objective: Move all corn to base; make sure at least one oil barrel has been moved to the farm.
Approach 1: We will build a robot that will travel to the model, lasso the corn, and bring it back to base.
Approach 2: We will build a robot that will travel to the model, skewer the corn, and return to base.
Requirements: We will need to create a robot that:

1. is mobile
2. can collect the corn and return to base.

Reasoning: We will have already transported an oil barrel to the base during the PERSONAL VEHICLE CHOICE mission. Moving the corn to base should be a simple case of dragging it home.

Mission 11: URANIUM MINING
Objective: Move all uranium out of farm (to base).
Approach 1: We will build a robot that will travel to the model, lasso the uranium, and bring it back to base.
Approach 2: We will build a robot that will travel to the model, skewer the uranium, and return to base.
Requirements: We will need to create a robot that:

1. is mobile
2. can collect the uranium and return to base.

Reasoning: Moving the uranium to base instead of just moving it away from the farm means we can use it for the POWER PLANT SUPPLY mission.

Mission 12: TREE PLANTING
Objective: Move trees to any area north of the river. They must remain upright. Individual pieces (bases) can be attached to individual trees.
Approach 1: We will build a robot that will push the trees into position.
Approach 2: We will build a robot that will push trees that have been attached to stands into position.
Requirements: We will need to create a robot that:

1. is mobile
2. can plough the trees into position without tipping them over.

Reasoning: We may reserve some trees for the POWER PLANT SUPPLY mission.

Mission 13: POWER PLANT SUPPLY
Objective: Move fuel (trees, black coal, green uranium, white oil barrels) to the Power Plant's property.
Approach 1: We will build a robot that will plough the green uranium, black coal, WIND TURBINES, and GRID CONNECTION to the power plant property and return to base.
Approach 2: We will build a container to hold the items. We will need to make sure it is completely in base. Doing it this way will require the WIND TURBINES and GRID CONNECTION to be separate just so we don't take everything on at once and risk losing a lot of points.
Requirements: We will need to create a robot that:

1. is mobile
2. can plough the objects into position without tipping them over.

Reasoning: We will likely plant the trees, and oil is more valuable in base than on the power plant property so it will not be delivered as fuel.